Fundamentals of Water Availability Modeling with WRAP

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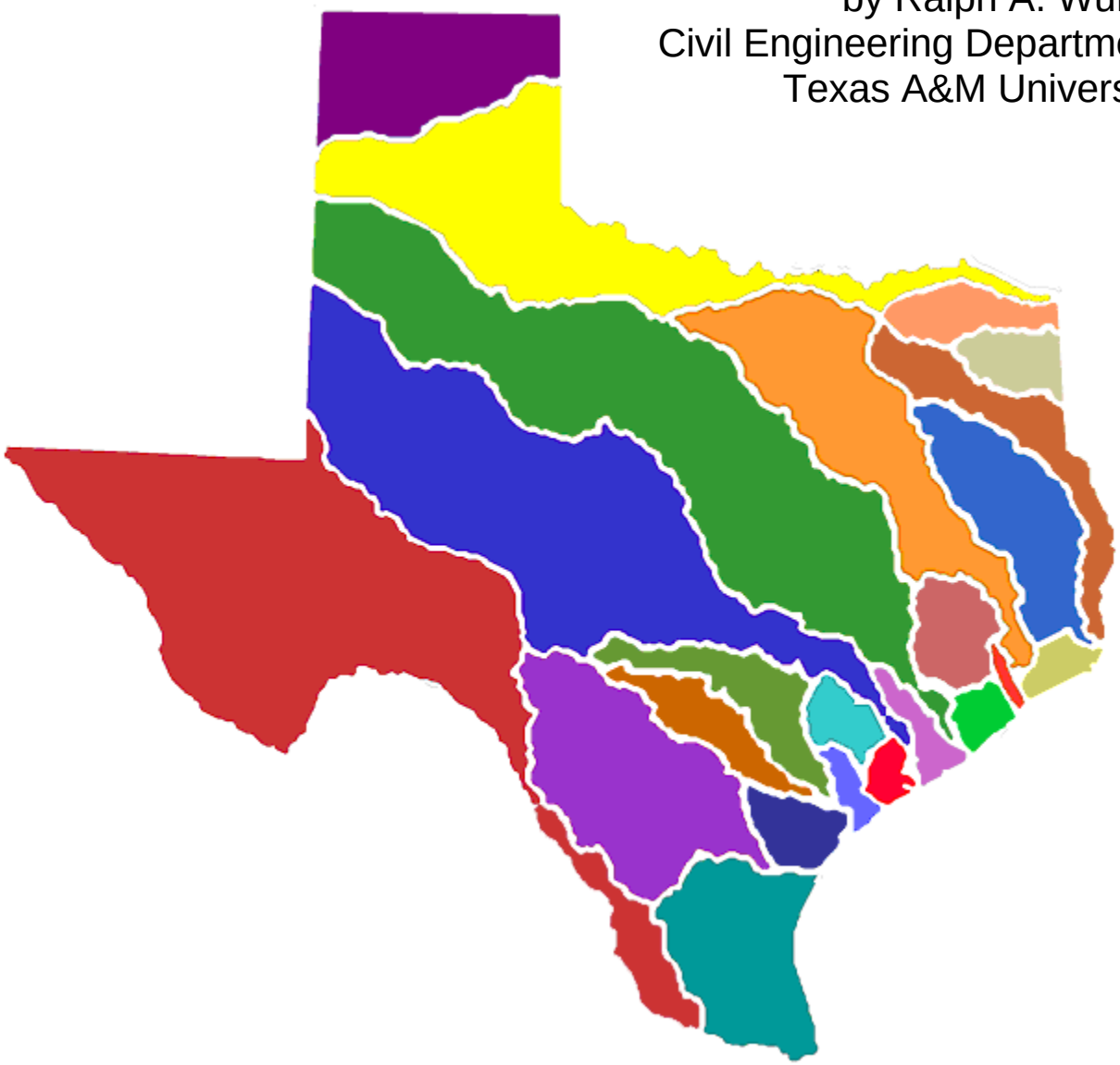

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Texas Water Resources Institute
make every drop count

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CHAPTER 1
WRAP MODELING SYSTEM

River/reservoir system management and water allocation practices are modeled with the Water Rights Analysis Package (WRAP) using historical naturalized stream flow sequences and net reservoir evaporation rates to represent river basin hydrology. The generalized simulation modeling system is used to evaluate hydrologic and institutional water availability/reliability in satisfying requirements for environmental instream flows, water supply diversions, hydroelectric energy generation, and reservoir storage. Flood control reservoir operations may also be simulated. Optional salinity tracking capabilities are provided. Basin-wide impacts of water resources development projects and management practices are modeled. The modeling system is generalized for application to any river/reservoir/water use system, with input datasets being developed for the particular river basin or multiple-basin region of concern.

The Texas Water Availability Modeling (WAM) System implemented and maintained by the Texas Commission on Environmental Quality (TCEQ) consists of the generalized WRAP model and input datasets for all of the river basins of the state. WRAP may be applied either in conjunction with the WAM System or independently thereof. In applying the Texas WAM System, model users modify the already-created WRAP input data files available from the TCEQ to model the alternative water resources development plans, water management strategies, and water use scenarios being investigated in their studies. For river basins outside of Texas, model users must develop the input datasets required for their particular applications.

Documentation

WRAP is documented in detail by the following manuals.

Reference Manual for the Water Rights Analysis Package (WRAP) Modeling System, TWRI TR-255, First Edition August 2003, Second Edition April 2005.

Users Manual for the Water Rights Analysis Package (WRAP) Modeling System, TWRI TR-256, First Edition August 2003, Second Edition April 2005.

Expanded WRAP Modeling Capabilities: Conditional Reliability, Sub-Monthly Time Step, Flood Control, and Salinity, TWRI TR-284, in preparation.

The *Reference* and *Users Manuals* and *Supplemental Reference/Users Manual* provide comprehensive detailed documentation of the modeling system. This *Fundamentals Manual* serves as an introductory tutorial helping new users to apply the model quickly for basic water availability modeling applications. With this abbreviated manual covering only select basic features, within a few hours, first-time users can become proficient in fundamental aspects of applying WRAP. The other manuals are required for proficiency in applying broader ranges of WRAP modeling capabilities. The *Fundamentals Manual* also provides a quick reference to basics for experienced users.

WRAP applications vary dramatically from quite simple to very complicated. Complexities are due primarily to requirements for flexibility in modeling diverse water

management strategies and reservoir/river system operating practices and the physical and institutional interrelationships between numerous water users and river regulation objectives. Modeling flexibility is provided through many optional features that are documented in detail in the other manuals. However, easy-to-learn fundamentals account for a significant portion of practical modeling applications. The basics covered here are fundamental for any WRAP application and represent all of the capabilities needed for many applications. The modeling system also provides considerable flexibility for compiling input data in various alternative formats. This manual addresses only the more conventional data format options.

Computer Programs

WRAP consists of the computer programs listed in Table 1.1. Executable files are distributed for use on desktop computers with the Microsoft Windows operating system. The public domain software and documentation may be freely copied. The programs *WinWRAP*, *SIM*, and *TABLES* are introduced in Chapters 2, 3, and 4. *WinWRAP* is a user interface that connects executable programs and data files. *SIM* is the basic simulation model. *TABLES* is a post-simulation program used to organize simulation results. The other programs described in Table 1.1 are not included in this manual. The executable programs are ready to run without any set-up procedure. The programs should be stored in the same directory or Windows folder.

Table 1.1 WRAP Programs

Program	File	Description
WinWRAP	WinWRAP.exe	Interface for applying WRAP on personal computers with the Microsoft Windows operating system.
SIM	SIM.exe	Generalized river/reservoir water allocation and management system simulation model.
SIMD	SIMD.exe	Expanded version of SIM with additional features for sub-monthly (daily) time steps, flow forecasting and routing, and flood control operations.
TABLES	TAB.exe	Post-simulation program for developing frequency relationships, reliability indices, and various user-specified tables and listings for organizing, summarizing, and displaying simulation results.
HYD	HYD.exe	Pre-simulation program for developing monthly naturalized stream flow and reservoir net evaporation rate data for SIM hydrology input files.
DAY	DAY.exe	Pre-simulation program for developing daily time step hydrology input for SIMD.
SALT	SALT.exe	Salinity simulation model.

Data Files

A complete listing of input and output data files for the WRAP computer programs is provided as Table 1.2 of the *Users Manual*. Selected files pertinent to the *Fundamentals Manual* are listed in Table 1.2 below.

Table 1.2 Input and Output Files

File Type	File Name	Description
		SIM Input Files
DAT	root1.DAT	Required input file containing data describing water resources development, management, and use.
FLO	root2.FLO	Monthly naturalized stream flows.
EVA	root2.EVA	Monthly net evaporation-precipitation depths.
DIS	root2.DIS	Watershed parameters for distributing naturalized flows from gaged to ungaged control points.
		SIM Output Files
OUT	root1.OUT	Main simulation results output file.
MSS	root1.MSS	Message file with trace, warning, and error messages.
YRO	root1.YRO	Yield-reliability analysis output table.
		TABLES Input Files
TIN	root3.TIN	Specifications controlling selection and format of tables or data listings to be created.
DAT	root1.DAT	*SIM* input file.
OUT	root1.OUT	*SIM* simulation results output file.
		TABLES Output Files
TAB	root4.TAB	Main output file with organized simulation results.
TMS	root4.TMS	Message file with trace, warning, and error messages.
DSS	root4.DSS	HEC-DSS file created by *TABLES*.
DSC	root4.DSC	Catalog of records stored in HEC-DSS file.

The WRAP programs are generalized for application any place, with the particular river basin hydrology and pertinent systems of rivers, reservoirs, water use requirements, and water management strategies and practices being described by sets of input data. A simulation is performed with *SIM* using input files of water right (DAT file) and hydrology (INF, EVA, DIS files) data provided by the model user. Program *TABLES* reads the *SIM* output OUT file and

organizes the simulation results in optional formats specified in a *TABLES* input TIN file. The organized simulation results are written to a *TABLES* output TAB file. Programs *SIM* and *TABLES* create message (MSS and TMS) files that track the computations and alert users to input data irregularities and errors. The executable WRAP programs and data files are interfaced through *WinWRAP* within the Microsoft Windows operating system in combination with use of Microsoft programs to access and edit WRAP input and output files.

Simulation results are written to files for analysis, incorporation into reports, or export to auxiliary programs for plotting or further manipulation, analysis, and display. With the exception of the binary HEC-DSS file, all of the input files read or output files created by WRAP programs are ordinary text files that may be read by any editor.

File names are in the format *root.extension*. The 3-character extensions listed in Table 1.2 define the type of data contained in the files. Extensions are set by naming conventions incorporated in the programs. The root is an arbitrary name assigned by the user. Programs and files are connected by *WinWRAP* with user-supplied file name roots when the programs are executed. The file name root is specified by the model-user through the beginning-of-execution log-in procedures managed by *WinWRAP*. All of the files used in a *SIM/TABLES* simulation may be named with the same root. Certain files used in a single execution must have the same file name root. Common or different file name roots may be assigned to files as follows:

- The same root may be used for all files associated with a particular simulation. The extension serves to differentiate between the different types of files that play various roles in the simulation.

- Assigning a different root (root2 in Table 1.2) for hydrology (FLO, EVA, DIS) files may be convenient though not required. In typical modeling studies, the hydrology files remain unchanged while the DAT file is varied in multiple simulations to reflect alternative water resources development plans, reservoir system operating strategies, or water use scenarios.

- Assigning different roots (root3 and root4 in Table 1.2) for *TABLES* input (TIN) and output (TAB and TMS) files may be convenient though not required when building selected sets of tables for various applications. Particular TIN files may be designed to create specific sets of tables in certain formats.

Files are composed of records or lines of data. The records contained in the input data files for the WRAP programs are organized by record type. An identifier entered at the beginning of each input data record defines the type of record. The various input data record types for *SIM* and *TABLES* are described in Chapters 3 and 4, respectively, and Appendices C, and D, respectively, of this manual. *SIM* input records begin with one of the two-character record identifiers listed in Table 3.1 of Chapter 3. *TABLES* records begin with the four-character identifiers listed in Table 4.1.

The WRAP modeling system is organized based on computer programs, data files, input records, and output tables. The organizational format of input records and files is designed to be both efficiently read by the computer and conveniently read by human analysts. Flexibility is provided for organizing and displaying simulation results in a myriad of format variations.

CHAPTER 2
WINWRAP INTERFACE

The *WinWRAP* interface is designed for running the WRAP programs within Microsoft Windows in an integrated manner along with use of Microsoft programs to access and edit input and output files and use of *MS Excel* or *HEC-DSSVue* to graph simulation results. The model user creates or obtains previously created files describing hydrology and water management in the river basin or region of concern along with specifications controlling the simulation. The input files are attached through *WinWRAP* to the generalized simulation model. *WinWRAP* provides an interface between the user and executable computer programs and also between the programs.

The WRAP programs (executable files) being used should be in the same directory (folder) as *WinWRAP*. A mouse click activates *WinWRAP*. The other programs are executed from *WinWRAP*, with the user providing the filename roots of the input and output data files. The *WinWRAP* menu structure provides the user the options shown in Table 2.1.

Table 2.1 WinWRAP Interface

WRAP Files	MS Programs	WRAP Programs	HEC-DSSVue
All WRAP Files	DOS Editor	SIM-TAB	HEC-DSSVue
----------	NotePad	SALT-TAB	HEC Website
Main Inputs	WordPad	HYD	
Main Outputs	Word	DAY	
Hydrology Inputs	Excel		
Special Outputs			
Messages			

DAT Files			
OUT Files			
TIN Files			
TAB Files			

Table 2.1 WinWRAP Interface (Continued)

File Building Aids	Information	Exit
TABLES DAT File	WinWRAP Instructions	Clear Screen
SIM DAT Template	WinWRAP Version	Exit
HYD DAT Template	WRAP Documentation	

	TCEQ WAM	
	TWRI	
	TAMU WRAP	

WRAP Files and Microsoft Programs

WRAP input data files may be created and edited with any editor. An optional built-in editor is provided in *WinWRAP* for the *TABLES* input TIN file. All other input files must be created with auxiliary software. Programs marketed by the Microsoft (MS) Corporation with their Windows and Office software packages are normally used to create and modify WRAP datasets. NotePad, WordPad, or Word are used in editing input files and viewing simulation results. Excel provides graphics and computational as well as editing capabilities. These MS programs are accessed directly from the *WinWRAP* interface. *TABLES* has options for tabulating any and all of the time series variables included in the simulation results in a format designed to be conveniently accessed by Microsoft Excel for plotting or other purposes.

As shown in Table 2.1, the first two pull-down menus on the *WinWRAP* desktop are labeled *WRAP Files* and *MS Programs*. Either may be used to activate Microsoft programs.

The *WRAP Files* pull-down menu provides access to data files through a Microsoft Windows window. Clicking or selecting/opening a data file activates the program such as NotePad or WordPad associated with the extension of the file. The Windows operating system provides mechanisms described in Windows Help for designating the program associated with any particular file extension. With Windows XP, an extension is assigned to WordPad, Notepad, or other programs by selecting any file with that extension. A right mouse click activates a menu that includes an *open with* option that activates a dialog box containing a check-box indicating that the file extension is to always be associated with the selected program.

The *MS Programs* pull-down menu is designed for opening the Microsoft programs listed in Table 2.1. A mouse click or select/open button activates the selected program. WRAP data files can then be opened from the Microsoft program.

WRAP Programs

Referring again to Table 2.1, the third pull-down menu on the *WinWRAP* desktop is labeled *WRAP Programs*. Any and all of the WRAP programs may be activated from this menu. A dialog box allows the user to select programs or combinations of programs and to enter filename roots. *SIM* and *TABLES* may be executed either singly or together.

HEC-DSSVue

The fourth pull-down menu on the *WinWRAP* desktop is labeled *HEC-DSSVue*. The program *HEC-DSSVue* may be activated from this menu. A menu selection is also provided to connect to the Hydrologic Engineering Center website.

The *HEC-DSS (Data Storage System)* is combined routinely with the popular suite of generalized hydrologic, hydraulic, and water management simulation models developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (USACE). *HEC-DSS* is used with other non-HEC modeling systems as well. The graphics and data management capabilities provided by the *HEC-DSS* are shared by multiple simulation models. The *HEC-DSS*

Visual Utility Engine (HEC-DSSVue) is a recently developed Java-based visual utilities program that allows users to plot, tabulate, edit, and manipulate data in a *HEC-DSS* database file. The customizable graphics produced by *HEC-DSSVue* can be saved in various formats, printed, or copied to the clipboard for inclusion in reports. *HEC-DSSVue* also incorporates various mathematical functions and provides utility functions for database management. The public domain *HEC-DSSVue* software and detailed users manual may be downloaded from the Hydrologic Engineering Center website: http://www.hec.usace.army.mil/

A HEC-DSS file is a direct access binary file that can be read only by HEC-DSS software such as *HEC-DSSVue*. The WRAP program *TABLES* is linked at compilation with a HECDSS library of routines allowing *TABLES* to store simulation results as HEC-DSS files. Either monthly or annual values of any of the time series variables in the *SIM* simulation results may be written by *TABLES* to a HEC-DSS file. HEC-DSS references data records by their pathnames, which consist of six parts in the format /A/B/C/D/E/F/. The pathname is assigned automatically by *TABLES* as indicated below.

A – filename root of *TABLES* output files
B – identifier of control point, water right, reservoir, or water right group
C – record identifier for *TABLES* input record such as 2NAT, 2REG, 2STO, etc.
D – date of the beginning of the time series such as 01JAN1940
E – time interval = MON or YEAR
F – CP, WR, Res, or WRG (control point, water right, reservoir, water right group)

File Building Aids

The fifth pull-down menu on the *WinWRAP* desktop is labeled *File Building Aids*. An editor is provided for creating or modifying a *TABLES* input *TIN* file specifying the selection and format options for the tables in which the simulation results are organized. This editing feature is the only editor that is actually constructed internally as a part of *WinWRAP*.

Templates are provided to help initiate construction of *SIM* and *HYD* input DAT files. The template is simply a text file with format information regarding several DAT file input records that serves as the beginning of a DAT file. Starting with a template may be a little easier than starting from scratch when creating a new DAT file.

Information

Referring once again to Table 2.1, the sixth pull-down menu on the *WinWRAP* desktop is labeled *Information*. The first selection in this menu is labeled *WinWRAP Instructions*, activation of which provides the text reproduced as Table 2.2.

WinWRAP Version simply provides the date of the version of *WinWRAP* being used. *WRAP Documentation* lists the manuals.

The last three entries in the *Information* pull-down menu activate websites. The Texas Commission on Environmental Quality (TCEQ) Water Availability Modeling (WAM) website has the WRAP software, input datasets for all the river basins of Texas, and various information

regarding the Texas WAM System. The software and datasets may be downloaded directly from the TCEQ WAM website. Information available for download from the Texas Water Resources Institute (TWRI) includes a number of technical reports related to WRAP and the Texas WAM System. The WRAP software and documentation can also be obtained directly from the referenced Texas A&M University (TAMU) Civil Engineering Department website.

Table 2.2 WinWRAP Instructions

Directories and Files

WinWRAP must be placed in the same directory as the WRAP executables.

The WRAP Programs menu allows input/output files to be selected either through the browse and click feature or by manually typing the filenames. The format of input/output filenames is root.ext. When manually entering filenames, the user types only the root if the files are stored in the same directory as the WRAP executables. The entire path name must be specified if the input and output files are in a different directory than the WRAP executables. The browse/click feature enters the full pathname automatically. After entering input filenames, a click of the output filename box will result in default output filenames being entered automatically.

WRAP executables will not accept directory paths containing blank spaces.

Program Execution

Menu selections are made with a click of the mouse. Menu hot keys may also be activated by pressing the Alt key along with the underlined letter of the menu item.

The WRAP Programs menu and Microsoft (MS) Programs menu in WinWRAP are used to select executable programs. To execute the WRAP programs, the user selects the dialog box for the program to be executed. The dialog boxes will save the last set of inputs.

When using the dialog boxes for executing the WRAP programs, clicking in the edit boxes for the output filenames will set the name to the input filenames. The user can change the output filenames manually if so desired.

File Builders

The File Building Aids menu provides an optional means of creating input files for the WRAP programs. The TABLES TIN File builder allows the user to interactively create and/or modify the input file used by tab.exe. The user can create a template to guide the construction of input files for SIM or HYD simulations by selecting the appropriate template menu items.

Note: The information in Table 2.2 is reproduced under *WinWRAP Instructions* accessible from the *Information* pull-down menu of *WinWRAP*.

CHAPTER 3
WRAP-SIM SIMULATION MODEL

SIM simulates the operation of river/reservoir systems and the management, allocation, and use of the water resources of a river basin or multiple-basin region. Water is allocated among multiple users based on specified priorities. The model provides an accounting system for tracking stream flow sequences, subject to reservoir storage capacities and specified diversion, instream flow, and hydroelectric power requirements. Stream flow and water in reservoir storage meet specified water right requirements subject to channel losses and losses or gains associated with evaporation from and precipitation onto reservoir water surfaces. Water balance computations are performed for each time step of the hydrologic simulation period. The model provides flexibility for adaptation to a broad range of modeling approaches. A conventional water availability modeling application of *SIM* is based on

- simulating capabilities for fulfilling specified water management and use requirements within the framework of constructed storage and conveyance infrastructure and institutional water allocation systems
- during an assumed hypothetical repetition of historical hydrology represented by sequences of monthly naturalized stream flows and reservoir net evaporation-precipitation rates covering the hydrologic period-of-analysis.

The component features of the *SIM* simulation model can be categorized as relating to either (1) natural river basin hydrology or (2) water resources development, management, allocation, and use.

- From the perspective of WRAP, river basin hydrology includes naturalized stream flows, reservoir net evaporation-precipitation rates, and channel losses.
- Water rights include all aspects of water resources development and management including water supply diversions, return flows, environmental instream flow requirements, hydroelectric energy generation, river regulation for flood control, reservoir storage on major rivers, off-channel storage, multiple-reservoir system operations, and intrabasin and interbasin conveyance.

Water availability modeling studies are performed with WRAP to evaluate capabilities of reservoir/river systems to meet specified water management/regulation/use requirements for given sequences of naturalized stream flows and reservoir net evaporation rates. Water management is combined with natural hydrology. Water managers are concerned with future not past hydrologic conditions. However, since the future is unknown, historical hydrology is used to capture the hydrologic characteristics of a river basin. The water management/use scenario might be actual current water use, projected future conditions, the premise that all permit holders use their full authorized amounts, hypothetical yields, or some other scenario of interest.

Input Records

The system for organizing *SIM* input datasets is based on files, records types, and fields in each record. Input files contain a set of required and optional records controlling various simulation

options and representing the river/reservoir/use system being modeled. The record types are labeled by a two-character identifier that is placed at the beginning of each record in the input files. Many typical applications will require only fundamental *SIM* capabilities using less than half of the 47 available record types. Twenty-three types of input records relevant to the modeling capabilities covered by this *Fundamentals Manual* are listed in Table 3.1 and described in detail in Appendix C.

Table 3.1
Types of SIM Input Records

	Basic Input File (filename root.DAT)
T1, T2, T3	*T*itles or headings at the beginning of the file that are reproduced in the output
**	comments or notes not read by the computer that may be inserted throughout
JD	*J*ob control *D*ata with basic data and option switches
JO	*J*ob *O*ptions controlling various features of the simulation
FY	*F*irm *Y*ield and yield-reliability table
WO, GO, CO, RO	*W*ater right, *G*roup, *C*ontrol point and *R*eservoir/hydropower *O*utput
ED	*E*nd of *D*ata
CP	*C*ontrol *P*oint connectivity and naturalized flow, evaporation, and channel loss data
UC	monthly water *U*se distribution *C*oefficients
WR	*W*ater *R*ight requirements
IF	*I*nstream *F*low requirements
WS	*W*ater right reservoir *S*torage
HP	*H*ydroelectric *P*ower parameters
SV/SA	*S*torage *V*olume (*SV* record) versus *S*urface *A*rea (*SA* record) table
PV/PE	*S*torage *V*olume (*PV* record) versus *E*levation (*PE* record) table for hydropower
	Hydrology Files (filenames root.FLO and root.EVA)
IN	*IN*flows to the system (naturalized stream flows)
EV	*EV*aporation (reservoir net evaporation-precipitation depths)

One each of five types of records (*JD*, *ED*, *CP*, *WR* or *IF*, and *IN*) are required. The other records are optional. Various fields on most records are either optional or have default values and may be left blank in many applications. The *Users Manual* provides detailed explanations of input records which are reproduced in abbreviated form in Appendix C of this *Fundamentals Manual* for the records listed in Table 3.1. Most of the 24 other *SIM* input record types omitted from this manual activate options providing greater flexibility for modeling complex reservoir/river system operations and water management situations. Several of the record types omitted here are designed for transferring naturalized stream flows from gaged to ungaged sites. Ingenuity is applied in combining options activated by the different records to model unique situations. The system of record types is designed to create comprehensible, documented datasets that can be conveniently analyzed and modified by model-users as well as efficiently executed by the computer.

Simulation Results

The voluminous output for each month of a *WRAP-SIM* simulation includes:

- naturalized, regulated, and unappropriated flows for each control point
- return flows from diversions that are returned at each control point
- channel losses and loss credits for the stream reach below each control point
- diversions, diversion shortages, and return flows for each water right
- hydroelectric energy generated and energy shortages
- instream flow targets and shortages
- storage and net evaporation-precipitation for each reservoir, right, and control point
- amount of water available and stream flow depletions for each right

Simulation results are written to the main *SIM* output file (filename root.OUT), which is read by *TABLES*. The program *TABLES* computes water supply and hydropower reliability indices and stream flow and storage frequency relationships and organizes the simulation results as tables of information in various user-specified optional formats.

For each month of a *SIM* simulation, output records are written for user-selected water rights (diversion right or instream flow right), control points, and reservoir/hydropower projects. The *WO*, *GO*, *CO*, and *RO* input records and *JD* record fields 5 and 6 control the selection of water rights, control points, and reservoir/hydropower projects to include in the simulation results output file. The OUT file output records contain the data listed in Table 3.2.

Table 3.2
Variables in the SIM Output File

Diversion Rights	Instream Flow Rights	Control Points	Reservoir/Hydropower
diversion target	instream flow target	naturalized flow	energy generated
diversion shortage	flow shortage	regulated flow	energy shortage
Storage volume	storage volume	unappropriated flow	secondary energy
evap-precip volume	evap-precip volume	stream flow depletion	storage volume
available stream flow	available stream flow	channel loss	evap-precip volume
stream flow depletion	stream flow depletion	channel loss credit	evap-precip depth
reservoir releases	required res release	reservoir releases	reservoir inflow
return flow	reservoir release	return flow	reservoir release
water right identifier	res release shortage	diversion target	turbine flow
two group identifiers	water right identifier	diversion shortage	reservoir identifier
		storage volume	
		evap-precip volume	
		cp identifier	

Some data are unique to water right, control point, or reservoir/hydropower output records. For example, naturalized, regulated, and unappropriated flows, and channel losses are associated only with control points. Other data are repeated on two or three of the record types. For example,

reservoir storage and evaporation are written to all three record types. If one water right with one reservoir is located at a control point, reservoir storage will be identical on all three records. The diversions and shortages on a water right output record are associated with a single *WR* input record. However, the control point records contain the summation of storage contents of all reservoirs assigned to the control point. Diversions and shortages on a control point record are the totals for all the rights assigned to the control point. Likewise, multiple water rights may be assigned to the same reservoir with certain variables summed for the reservoir/hydropower record.

Control points, water rights, and reservoirs are the building blocks used to structure the model from the perspectives of both data management and computations. There are no limits on the number of control points, water rights, and reservoirs that may be included in a dataset.

Control Points

The spatial configuration of a river system is defined by a set of control points. Each control point has a *CP* record in the DAT file, which includes identifiers of that control point and its next downstream control point. This defines the spatial connectivity of the system. Essentially any configuration of stream tributaries and conveyance systems may be modeled. All reservoirs, diversions, return flows, hydropower plants, environmental instream flow requirements, and other system components are assigned control point locations. The control point assigned to a water right is the location at which the right has access to stream flow.

Primary control points are the locations at which naturalized stream flows are provided as *IN* records in the input dataset. Secondary control points are locations at which naturalized flows are computed by *SIM* based on the flows at primary control points and watershed parameters.

River Basin Hydrology

River basin hydrology is represented in *SIM* by sequences of naturalized stream flows and reservoir net evaporation less precipitation depths for each month of the hydrologic period-of-analysis at each pertinent location. Net reservoir evaporation-precipitation depths are entered on *EV* records in an EVA file. Naturalized flows for primary control point locations are provided as input on inflow *IN* records in a FLO file. Alternative methods for computing naturalized flows at ungaged locations (secondary control points) based on flows at primary control points (*IN* records) and watershed parameters read from a flow distribution (DIS) file are described in the *Reference* and *Users Manuals* but are not covered in this *Fundamentals Manual*. The model is based on total stream flows, rather than incremental inflows. However, methods outlined in the other manuals are provided to address the issue of negative incremental naturalized flows.

SIM simulates capabilities for meeting water management and use requirements during a hypothetical repetition of historical natural hydrology. For example, a simulation might be concerned with assessing reliabilities in meeting a specified set of annual water use requirements (with seasonal variations over the 12 months of the year) during a repeat of historical hydrology represented by sequences of naturalized stream flows and reservoir net evaporation rates for each month of the 780-month 1940-2004 hydrologic period-of-analysis.

The future is of concern, rather than the past. However, since future hydrology is unknown, historical natural stream flows and reservoir evaporation-precipitation rates are adopted as being representative of the hydrologic characteristics of a river basin that can be expected to continue into the future. A typical hydrologic period-of-analysis used for studies in Texas is 1940 to near the present. This period includes the 1950-1956 most severe drought-of-record as well as a full range of fluctuating wet and dry periods. Water resources are highly variable and highly stochastic or random, subject to extremes of droughts and floods as well as continuous more normal fluctuations. Major droughts typically involve long periods with sequences of many months of low flows. A basic premise of the conventional modeling approach is that historical naturalized stream flows and evaporation-precipitation rates for an adequately long period-of-analysis capture the essential statistical characteristics of river basin hydrology.

Channel losses are included in various aspects of the simulation computations, based on loss factors F_{CL} entered on the control point *CP* records.

$$\text{flow loss} = F_{CL}\, Q_{upstream} \tag{3.1}$$

The channel loss factor F_{CL} is defined above, where $Q_{upstream}$ is the flow at the upstream control point of a river reach between two control points, and flow loss refers to the loss in the reach. Channel losses represent seepage, evapotranspiration, and other otherwise unaccounted losses.

Water Rights

In WRAP terminology, water resources development facilities, water use requirements, and river/reservoir system operating policies and practices are described in terms of water rights. *SIM* provides capabilities for modeling water management/use systems consisting of:

- reservoir projects operated to regulate and conserve stream flow including multiple-reservoir systems, off-channel storage, and flood control, pumping/conveyance facilities, and hydroelectric power plants
- requirements specified in water right permits
- requirements specified in water supply and hydropower contracts, interstate compacts, international treaties, and other agreements
- system operating policies and rules
- water use characteristics and practices

In WRAP, a water right is a set of water management and use requirements associated with either a water right *WR* record or an instream flow *IF* record. Water supply diversion and hydroelectric energy generation are specified as *WR* record rights. Instream flow requirements are specified as *IF* record rights. The number of water rights counted by *SIM* is simply the number of *WR* and *IF* records included in the DAT input file.

Other types of input records describing various aspects of the river/reservoir/water use system follow the *WR* or *IF* record for a particular water right in the input file and are connected to the right in the simulation computations. The *WS* record describing reservoir storage and *HP* record

providing hydropower data are covered in this *Fundamentals Manual*. Other record types connected to *WR* and *IF* records that are not covered by this manual include the supplemental options *SO*, dual simulation and transient options *DT*, target options *TO*, target series *TS*, monthly limits *ML*, operating rules *OR*, evaporation allocation *EA/EF*, and drought index *DI/IS/IP* records. Ingenuity in combining water right *WR*, instream flow *IF*, and supporting input records to model a particular water management situation is important in applying WRAP.

The set of information specifying the water management and use requirements defining a particular water right may include the following.

- identifiers of the control point locations of pertinent components
- priority number
- annual diversion target
- return flow specifications
- instream flow specifications
- annual hydroelectric energy generation target
- set of monthly water use distribution coefficients
- set of rules for varying diversion, instream flow, and hydroelectric energy targets as a function of stream flow or storage subject to specified limits
- drought index for varying targets as a function of reservoir storage
- active and inactive reservoir storage capacity
- reservoir storage volume versus surface area relationship
- reservoir elevation versus storage volume relationship
- reservoir/river system operating rules
- off-channel reservoir storage
- interbasin or intrabasin conveyance
- annual and monthly limits on stream flow depletions
- annual limits on total diversions or diversions from storage
- identifiers for labeling rights and aggregating simulation results for groups of related rights

Water Right Priorities

A fundamental concept of the model is that available stream flow is allocated to each water right in turn in ranked priority order. Priority numbers serve the important function of setting the order in which the rights are considered in the water rights computational loop that allocates water. However, the priorities are used in no other way. Diversion, instream flow, hydropower, and storage refilling targets for each right are met to the extent allowed by available stream flow and storage prior to considering the requirements of more junior rights. The seniority of a right relative to other rights is expressed by their priority numbers. In comparing two rights, the senior right has a lower priority number than the junior right. *Junior* and *senior* are relative terms used in the context of comparing the priority of two water rights. The magnitude of the priority numbers for each of the rights relative to each other govern the order in which water is allocated among the rights.

Within the *SIM* computations, priority numbers have meaning only in a relative sense. In the Texas prior appropriation water rights permit system, priority numbers typically represent dates

specified in the permits. For example, a priority date of March 12, 1982 specified in a water right permit is entered in the *WR* record as the integer 19820312, which is a larger number than the priority corresponding to any earlier date. With a little ingenuity, model-users can devise various other schemes for using the priority numbers to model relative priorities for allocating water.

Priorities are integer numbers normally specified on each *WR* and *IF* record. If two or more water rights have the same priority number, they are ranked in the same order as their *WR* or *IF* records are entered in the input file. Alternatively, the natural priority option assigns priorities internally in upstream-to-downstream order. Priorities may also be controlled for water use type groups using use priority *UP* records. With either of these options, each *WR* and *IF* record water right is assigned an integer number. Smaller numbers mean higher priority, rank, or seniority.

Diversion, Instream Flow, and Hydropower Targets

The terms *target*, *requirement*, *demand*, and *permitted amount* are used interchangeably. A diversion target entered on a *WR* record represents water withdrawn from the river/reservoir system for water supply. An energy generation target is specified on a *WR* record for a hydroelectric power right. An instream flow requirement specified on an *IF* record is a target minimum regulated monthly flow at a control point location. Other *WR* record water rights with priorities junior to an instream flow requirement are not allowed to appropriate water that results in violating the minimum flow limit set by the *IF* record.

Water supply diversion, hydroelectric energy generation, and instream flow targets are specified in terms of an annual amount input on a *WR* or *IF* record combined with a set of 12 monthly use coefficients entered on *UC* records for distributing the annual amount over the 12 months of the year. Thus, water use requirements are expressed as monthly targets that may vary each month from January through December but are constant from year to year. Model options not covered in this manual allow diversion, instream flow, and hydropower targets to be also defined as a function of reservoir storage and/or stream flow and thus allowing variations between years.

WR Record Water Right Types

WR record field 6 provides a categorization scheme for specifying certain basic rules for meeting diversion or hydroelectric energy requirements from stream flow and reservoir storage and for refilling reservoir storage. The kinds of reservoir/river system operations associated with the water right type parameter are as follows.

water supply diversion from stream flow	types 1, 2
diversion from reservoir storage/releases	types 1, 2, 3
inflows discharged into river system	type 4
hydropower generation from stream flow	types 5
hydropower generation from releases	types 5, 6
refilling of storage in one reservoir	types 1, 5

Type 1 right.- The default type 1 right allows a diversion to be met from stream flow depletions and/or storage in one or more reservoirs. A diversion requirement is met first from

stream flow, if available, and then from reservoir storage if stream flow is not available. One reservoir, called the primary reservoir, can be refilled from stream flow depletions or releases from other reservoirs in the system. The primary reservoir that can be refilled and the diversion must be located at the same control point. Any number of other secondary reservoirs in the system, from which releases are made, can be located at any of the control points. A storage-only right may simply refill storage in the one reservoir, having a diversion requirement of zero. A run-of-river diversion right can be represented as a type 1 right with zero active reservoir storage capacity.

Type 2 right.- A type 2 right is identical to a type 1 right except that reservoir storage is not refilled. Reservoirs may be used along with stream flow to meet diversion requirements, but other water rights (*WR/WS* records) are used to refill storage.

Type 3 right.- A type 3 right is identical to a type 2 right except the diversion target can be met only by releases or withdrawals from reservoir storage. A diversion can be met by releases from any number upstream reservoirs without allowing diversion of unregulated stream flow entering the river below the dams. Unlike a type 3 right, a type 1 or 2 right makes reservoir releases only after the stream flow at the diversion location is depleted.

Type 4 right.- With a 4 entered in field 6 of the *WR* record, the annual amount entered in *WR* record field 3 is discharged into the stream. The target amount is computed for a type 4 right just like any other type of right. The difference is that a type 4 right is not a diversion from the stream, but rather an inflow to the stream. A type 4 right may model a interbasin transfer, return flow, or other situations involving discharge of water into the stream system within the water rights priority computation loop.

Type 5 right.- A 5 or 6 is entered in *WR* record field 6 for a hydroelectric power right. A type 5 hydropower right is identical to a type 1 right except a hydroelectric energy requirement is specified rather than a diversion. A run-of-river hydropower right can be represented as a type 5 right with one reservoir with inactive but no active storage capacity.

Type 6 right.- A type 6 right is identical to a type 5 right except the hydroelectric energy requirement can be met only by releases from reservoir storage. A type 6 hydropower right is analogous to a type 3 diversion right.

Reservoirs

Each reservoir is associated with at least one *WR* record water right. Any number of *WR* record and *IF* record water rights may be connected to the same reservoir. The total storage capacity and inactive storage capacity from the *WS* record and operating rules from *OR* records may vary between water rights at the same reservoir. Any number of reservoirs may be connected to a single water right, with multiple-reservoir system operating rules governing release decisions each month. Each reservoir has one and only one control point location. Multiple rights and multiple reservoirs may be assigned to the same control point. Each water right has access, in priority order, to available stream flow at the control point.

A *WRAP-SIM* water right may include (1) maintaining or refilling storage in one reservoir and (2) meeting diversion, hydropower, or instream flow requirements by diverting or releasing

from storage in any number of reservoirs. In constructing a model, these two aspects of reservoir operations can be viewed as essentially separate actions. A particular right may include either, neither, or both. Reservoir storage capacity is provided on the *WS* record associated with a water right. Any number of water rights can be associated with a single reservoir, with each right filling the reservoir to a different storage capacity and/or using the reservoir to meet its water use requirements. *SIM* allows releases from multiple reservoirs to meet the one diversion, hydropower, or instream flow target and maintain storage in the one reservoir specified by a single water right.

The *WR* and *WS* records are identical for either on-channel or off-channel storage. However, supplemental options *SO* and monthly limits *ML* records activate options that place monthly or annual limits on the amount of stream flow that may be appropriated to fill storage. These limits are designed for off-channel reservoirs to model the pumping and conveyance capacity of the facilities that convey water from the river to the off-channel reservoir. Stream flow is appropriated to refill storage the same for an off-channel reservoir as for a reservoir impounded by a dam on the river with the exception of the options to impose conveyance limits.

A storage volume versus water surface area relationship is assigned to each reservoir either as a table on *SV/SA* records or as Equation 3.2 with coefficients a, b, and c provided on a *WS* record.

$$A = aS^b + c \tag{3.2}$$

S and *A* denote storage volume and area. The storage/area relationship is used solely for determining net evaporation-precipitation volume, which for a given month is the product of the computed average water surface area during the month and the appropriate net evaporation rate from *EV* records. An elevation versus storage volume table is provided on *PE/PV* records for any reservoir associated with hydropower for use in determining head. The model uses linear interpolation with the *SV/SA* and *PE/PV* record tables.

By default, all reservoirs are assumed to be full to their maximum storage capacity at the beginning of the simulation. However, a less than capacity beginning storage content for any reservoir may be specified on its *WS* record. A set of beginning-ending storage (BES) options activated by the *JO* record sets beginning storage equal to estimated end-of-simulation storage.

The storage capacity associated with each *WR/WS* records is the total cumulative capacity to which the reservoir can be refilled under that right's priority, assuming the reservoir has been drawn down in previous months and stream flow is now available for refilling. Multiple reservoirs may also be associated with a single water right. However, a right may include a storage capacity to be refilled in only one reservoir, called its *primary* reservoir. *Secondary* reservoirs supply water use requirements but are not refilled by the right. A secondary reservoir supplying water for a particular water right is the primary reservoir for another right which refills storage. Multiple water rights with different priorities may fill different storage capacities in the same reservoir. A senior right must have a storage capacity equaling or exceeding other junior rights at the same reservoir.

An inactive pool capacity may also be designated on the *WS* record. In the simulation computations, no releases are made from the inactive pool. The storage level is allowed to fall below the top of inactive pool only due to evaporation. The designated inactive pool storage capacity may vary with different water rights at the same reservoir.

Stream Flow

The *SIM* simulation process consists of a series of adjustments to stream flow sequences covering the hydrologic period-of-analysis, which involves three forms of stream flows at each control point: naturalized, regulated, and unappropriated. A *SIM* simulation begins with naturalized flows provided on *IN* records for primarily control points. Naturalized flows may be distributed to secondary control points within the model. Regulated and unappropriated flows are computed for all control points. The computations are based on total cumulative flows, not incremental flows.

In general, the terms *naturalized*, *unregulated*, or *unimpaired* refer to sequences of past stream flows adjusted to represent a specified condition of river basin development that includes either no human impact or some defined level of development. Naturalized flows are ideally natural flows that would have occurred historically, in the absence of the water management activities reflected in the water rights input data, but with all other aspects of the river basin reflecting a prescribed fixed scenario.

Regulated and unappropriated flows computed by SIM reflect adjustments to naturalized flows for water right requirements representing a specified scenario of water resources development and use. Regulated flows are physical flows considering all water rights in the input dataset. Unappropriated flows are available for further appropriation after all the water rights receive their allocated share. Regulated flows may be greater than unappropriated flows due to instream flow requirements at the site or commitments to other rights at downstream control points.

The adjustments that convert naturalized flows to regulated flows include both stream flow depletions and return flows. Stream flow depletions are the quantities of water appropriated to meet water supply diversion requirements and refill reservoir storage. Return flows are added back to stream flows. Channel losses are considered as stream flow adjustments are cascaded downstream.

Simulation Algorithms

The simulation tasks performed by *SIM* are outlined in Figure 3.1. After initial organization of the simulation, computations are performed in a water rights priority loop that is embedded within an annual and monthly time step loop.

Model execution begins with reading and organizing input data. Water rights are sorted into priority order. The simulation steps through time. At the beginning of each year, naturalized flows for primary control points and net reservoir evaporation rates are either read or activated from a previously read array. Flows are distributed from primary control points to all other secondary control points based on watershed parameters. Within each sequential month, water accounting computations are performed as each set of water use requirements (water right) is considered in priority order. Water allocation and management are modeled by accounting procedures within the water rights priority loop. An array is maintained of stream flow available for appropriation at all control points. As each right is considered in priority order, the following tasks are performed.

1. The diversion, instream flow, or hydropower target is set starting with an annual amount and set of 12 monthly distribution factors provided as input. The target may be

further modified as a function of the storage content in any number of specified reservoirs and naturalized, regulated, or unappropriated flow at any control point.

2. The amount of water available to the water right from stream flow is determined based on the available stream flow array considering the control point of the water right and all downstream control points.

3. Water use requirements are met subject to water availability following specified system operating rules. Water accounting computations determine the diversion, diversion shortage, end-of-month storage, and related quantities. Reservoirs and hydropower plants necessitate an iterative algorithm since evaporation and hydropower releases are a function of both beginning-of-month and end-of-month storage.

4. The available stream flow array is adjusted for that location and all downstream sites to reflect the effects of the water right. Channel loss factors are applied in translating adjustments for stream flow depletions and return flows to flows at downstream control points. Within the priority loop, the available flow array is used to determine the amount of water available to each individual right. At the end of the month, the available flow array is used to determine regulated and unappropriated flows.

- Main input file containing water rights data is read.
- Water rights are ranked in priority order.
- Various other data manipulations are performed.
- Flow distribution file containing watershed parameters is read.
- Watershed parameters are determined for incremental watersheds.

Annual and Monthly Simulation Loop

* Naturalized flow and net evaporation rates are read or activated.
* Naturalized flows are transferred from gaged to ungaged sites.

Water Right Priority Loop

1. Diversion, instream flow, or hydropower target is set.
2. Water availability is determined from available flow array.
3. Operating decisions and water balance in an iterative loop.
4. Available stream flow array is adjusted for effects of right.
5. Simulation results for this water right are recorded.

* Simulation results for control points are recorded.
* Simulation results for reservoirs/hydropower plants are recorded.

Figure 3.1 Outline of Simulation Performed by *SIM*

Water Availability in the Water Rights Priority Loop Computations

The concept of water allocation computations being performed in a water rights loop is fundamental to the *SIM* simulation approach. The requirements of each individual right are met in priority order. Thus, in a particular month, senior rights affect the amount of water available to junior rights but basically are not adversely affected by the junior rights. However, fluctuating decreases and increases in water availability are a complexity in applying *SIM*. In reality, junior rights may increase the amount of water available to senior rights. Modeling complications may occur involving senior rights not getting access to water made available by junior rights through:

1. same-month return flows from diversions from storage
2. same-month hydroelectric power releases
3. contributions to meeting instream flow requirements at intermediate control points made by releases from upstream reservoirs to meet diversions at downstream locations

As each water right is considered in priority order in the water rights computational loop, regulated flows and the flows available to more-junior rights usually decrease but may also increase. Diversions and reservoir storage decrease flows at their control point and at downstream control points. Conversely, flows are increased by hydropower releases and return flows from diversions from storage. Reservoir releases may increase flows at intermediate control points between the reservoir and downstream diversion site. A diversion and/or storage right may be unnecessarily curtailed (shorted) due to computationally not having access to water made available by more junior rights in the form of return flows or hydropower releases. Likewise, reservoir releases that increase flows at intermediate control points between the reservoir and downstream diversion site may not be properly credited as contributing to instream flows at the intermediate control points. Junior diversion and storage rights may be unnecessarily curtailed to maintain senior instream flow requirements.

Several *SIM* options have been adopted in practice to deal with the complexities of fluctuating decreases and increases in water availability in the water rights priority loop. The next-month return flow option makes the return flows available in the next month at the beginning of the water rights loop. Thus, all rights have access to the return flows in priority order. Likewise, entering return flows as constant inflows on *CI* records makes the flows available at the beginning of the water right computations. The next-month hydropower option makes hydropower releases available to senior rights located downstream. The optional second-pass features associated with instream flow (*IF* record) rights addresses this same complexity. These options involve model features described in detail in Chapter 4 of the *Reference Manual*.

Units of Measure

Any consistent set of units may be used. Conversion factors are entered on the *XL* record if needed to achieve consistent units. Typical English units requiring no conversion factors are acre-feet for storage volume and volume/month and volume/year quantities, acres for reservoir surface area, and feet for net evaporation depth. Typical metric units are million cubic meters for volume, square kilometers for reservoir surface area, and meters for net evaporation depth.

Simulation Example

The hypothetical example presented here was created by excerpting hydrology and reservoir data from the Texas WAM System dataset for the Brazos River Basin and adding other fabricated water rights data to develop a realistic but reasonably simple illustrative example. Information for the concocted example is presented in Figure 3.2 and Table 3.3. The river basin system has 11 control points, six reservoirs, and 30 water rights. The *SIM* input and output data files are presented in Appendix A. The *TABLES* input and output files are reproduced as Appendix B.

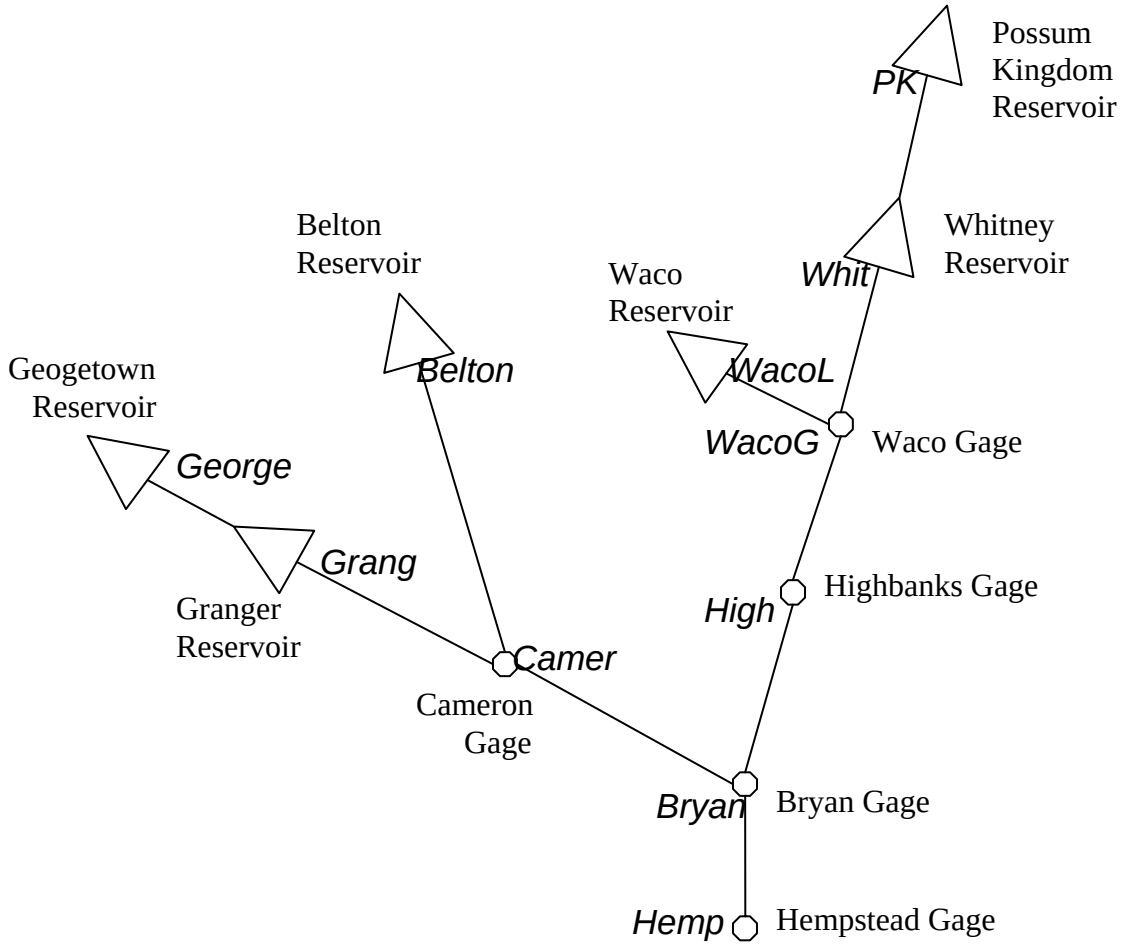

Figure 3.2 System Schematic for the Example

Both control points and reservoirs are labeled in a *SIM* dataset with identifiers that are limited to not exceed six characters in length. The identifiers for the 11 control points are shown in the above schematic. Normally reservoir identifiers are different than control point identifiers. However, for simplicity, for the six reservoirs, the identifiers for their control points are also adopted as the reservoir identifiers. Water rights have identifiers limited to not exceed 16 characters. Identifiers for the 30 water rights are listed in Column 1 of Table 3.3.

Table 3.3 Water Rights in the Example

1 Water Right ID	2 Control Point ID	3 Reservoir ID	4 Priority Number	5 Diversion Target (ac-ft/yr)	6 Energy Target (kW-hrs/yr)	7 IF Target (ac-ft/yr)	8 Storage Target (ac-ft)
IF-1	Camer		0			3,600	
IF-2	Hemp		0			120,000	
WR-1	PK	PK	193804	9,800			570,240
WR-2	PK	PK	193804	245,000			570,240
WR-3	Whit	Whit	198208	18,000			627,100
WR-4	Whit	Whit	888888		36,000		627,100
WR-5	WacoL	WacoL	192901	59,100			104,100
WR-6	WacoL	WacoL	197902	900			104,100
WR-7	WacoL	WacoL	198609	20,800			192,100
WR-8	Belton	Belton	196312	82,760			457,600
WR-9	Belton	Belton	196312	97,500			457,600
WR-10	George	George	196802	25,610			37,100
WR-11	Grang	Grang	196802	42,000			65,500
WR-12	Camer		198211	92,100			
WR-13	Camer		196105	18,200			
WR-14	Camer		194510	11,300			
WR-15	Camer		200601	88,000			
WR-16	WacoG		194607	32,300			
WR-17	High		195903	44,800			
WR-18	Bryan		198211	25,400			
WR-19	Bryan		196105	39,000			
WR-20	Bryan		194510	34,500			
WR-21	Hemp		196105	95,600			
WR-22	Hemp		194510	49,600			
WR-23	Hemp		200601	74,500			
WR-24	Hemp		200601	900,000			
WR-25	PK	PK	999999				570,240
WR-26	Belton	Belton	999999				457,600
WR-27	George	George	999999				37,100
WR-28	Grang	Grang	999999				65,500

Files for the example are listed in Table 3.4. The *SIM* input (DAT, FLO, EVA) and output (MSS, OUT, YRO) files are presented in Appendix A. The *TABLES* input (TIN) and output (TMS, TAB) files are presented in Appendix B. Program *TABLES* reads the *SIM* output OUT file as an input file. The content and format of the *SIM* and *TABLES* input records are explained in Appendices C and D, respectively. The electronic input data files for this example are distributed along with the files for the other examples presented in the *Reference Manual*.

Table 3.4 Files for the Example

Filename	Pages	Description
Example.DAT	39-41	All *SIM* input except the *IN* and *EV* records.
Example.FLO	42	*IN* records for the 11 control points for 1940-1997.
Example.EVA	43	*EV* records for the 6 control points with reservoirs.
Example.MSS	44	*SIM* message file.
Example.OUT	45-46	*SIM* simulation results.
Example.YRO	47	*SIM* yield-reliability table created with *FY* record.
Example.TIN	49	*TABLES* specifications for building tables.
Example.TMS	50	*TABLES* message file.
Example.TAB	51-64	Simulation results as organized by *TABLES*.

Input data for program *SIM* have been compiled in files with filenames Example.DAT, Example.FLO, and Example.EVA. The DAT file reproduced in Appendix A on pages 39-41 contains all of the *SIM* input data except the *IN* and *EV* records. The first part of the FLO file containing the *IN* records is on page 42. The first part of the EVA file containing the *EV* records is on page 43. The MSS, OUT, and YRO files produced by *SIM* are also included in Appendix A on the pages listed in Table 3.4.

Appendix C of this *Fundamentals Manual* contains explanations describing the 23 types of *SIM* input records of which 20 types are used in the example. The *Users Manual* provides instructions for all 47 types of *SIM* input records. These descriptions of record content and format are essential for applying the model. In studying the example dataset, the explanations in Appendix C should be reviewed concurrently with the corresponding records in the input files.

*T1, T2, T3, **, JD, JO, and RO Records in the SIM DAT File (pages 39 and 65-67)*

The DAT file begins with three optional title records (*T1*, *T2*, and *T3*). The information provided on the title records is printed at the beginning of the output file but does not affect the simulation computations. Comment records starting with ** are used throughout the DAT file for the benefit of model users. The computer does not read records starting with **. Comment records are used to organize and document input files. The ** notation is also used to deactivate records that are not to be used in the current execution of the model. For example, the 14th record of the DAT file on page 39 is a firm yield *FY* record which is not applicable for the first simulation discussed here but controls the yield-reliability analysis discussed later in this chapter. The *FY* record has been temporarily deactivated by adding the ** at the beginning.

The job data *JD*, job options *JO*, and reservoir output *RO* records are described on pages 66, 67, and 69, respectively. The 58 year hydrologic period-of-analysis extends from 1940 through 1997. ICHECK of 1 in *JD* record field 4 activates a standard level of error checks and trace messages. Negative incremental flow option 4 selected in *JD* record field 8 is the standard

option that should be used in most applications. *JO* record field 2 specifies options for organizing the *IN* and *EV* records by grouping them by control point in FLO and EVA files.

Simulation results written to the OUT file consists of the 1940-1997 monthly time series variables listed in Table 3.2. *JD* record fields 5 and 6 and *CO*, *WO*, *GO*, and *RO* records are used to select the control points, water rights, and reservoirs for which simulation results are included in the OUT file. The *CO*, *WO*, and *GO* records are the only record types included in Appendix C that are not used in the example. In this example, output records are written to the OUT file for all control points and reservoirs and all water rights except the hydropower right. For larger datasets with thousands of water rights and control points and hundreds of reservoirs, the OUT file can be extremely large, increasing both computer memory requirements and run times. Limiting the OUT file to only data that is actually of interest in the study can also simplify the *TABLES* TIN file by allowing *TABLES* to include all water rights, control points, and reservoirs from the *SIM* OUT file in its tables.

UC Records in the SIM DAT File (pages 39 and 71)

The water use coefficient *UC* records contain a water use identifier corresponding to field 4 of the instream flow *IF* and water right *WR* records and a set of 12 coefficients for distributing the annual target in field 3 of the *IF* and *WR* records over the 12 months of the year. Fractions summing to 1.0 are computed by dividing each coefficient by the sum of all 12 coefficients. If *IF* or *WR* record field 4 is blank, 1/12 of the annual target is distributed to each month. If *IF* or *WR* record field 4 contains the entry NDAYS, the annual target is automatically distributed over the 12 months in proportion to the number of days in each month, which is either 29, 30, or 31.

In the example, monthly targets are set by simply multiplying the annual target from the *WR* or *IF* records by fractions computed from the use coefficients from *UC* records. However, other options described in the *Reference* and *Users Manuals* may be adopted to further modify the monthly targets as a function of stream flow or reservoir storage.

Control Point Records in the SIM DAT File (pages 39 and 72-73)

Each control point has an identifier that can not exceed six characters in length. The control point identifiers shown in Figure 3.2 are entered in *CP* record field 2 followed in field 3 by the identifier of the next downstream control point. These pairs of control point identifiers define the spatial connectivity of the river system. Methods for inputting or computing naturalized stream flows and net evaporation rates are specified on the *CP* record, with the blank fields in the example DAT file indicating defaults. Channel loss factors defined by Equation 3.1 are entered in field 10.

Water Right Records in the SIM DAT File (pages 39-41 and 74-80)

A water right consists of either an *IF* or *WR* record followed by a set of supporting records, which in this example includes one right with a *HP* record and several with *WS* records. The 30 water rights defined by two *IF* records and 28 *WR* records with associated *HP* and *WS* records are listed in Table 3.3. Several other types of optional records that may be combined

with *IF* and *WR* records to define water right requirements are described in the *Reference* and *Users Manuals* and also in the *Supplemental Manual* describing expanded capabilities.

The water rights with identifiers IF-1 and IF-2 are instream flow requirements. Water right WR-4 generates hydroelectric power. WR-12, WR-13, WR-14, WR-16, WR-17, WR-18, WR-19, WR-20, WR-21, WR-22, and WR-23 are run-of-river diversion rights with no reservoir storage. WR-1, WR-2, WR-3, WR-5, WR-6, WR-7, WR-8, WR-9, WR-10, and WR-11 are diversion rights that both refill and withdraw from reservoir storage. WR-15 and WR-24 are multiple-reservoir system diversion rights that do not refill storage. Reservoir storage is refilled by *WR*-25, *WR*-26, *WR*-27, and *WR*-28.

Priorities serve the sole purpose of setting the order in which water rights are considered in the simulation computations. With priority numbers of zero in *IF* record field 5, IF-1 and IF-2 are the most senior rights in the river basin. In each month, the first action taken in the priority-sequenced simulation is to set the instream flow targets of 300 acre-feet/month at the Cameron gage control point and 10,000 acre-feet/month at the Hempstead gage control point. All the other more junior rights are constrained from any water appropriations that would result in these minimum instream flow targets being violated. With priority numbers of 999999 in *WR* record field 5, *WR*-25, *WR*-26, *WR*-27, and *WR*-28 are the most junior rights in the basin. These rights refill storage in system reservoirs that has been depleted by more senior diversion rights. The other rights have priority numbers that represent dates in permits reflecting the prior appropriation water rights system. For example, water right WR-1 has a priority of 193804 reflecting a right dating back to April 1938. With more than one right having the same priority number in *WR* or *IF* field 5, the right entered first in the DAT file is treated as having higher priority, meaning it is considered first in the simulation computations.

Water right WR-15 is a diversion at the Cameron gage control point (CP identifier Camer) supplied by available stream flow at that control point supplemented by releases from Belton, Georgetown, and Granger Reservoirs which have reservoir identifiers of Belton, George, and Grang. The 88,000 acre-feet/year diversion target is distributed over the 12 months of the year using coefficients from the *UC* record with use identifier MUN2 representing municipal water use in that region. The priority number for WR-15 is 200601 representing a permit filing date of January 2006. Return flows are 35% (from *WR* field 8) of the diversion. Return flow method 2 in *WR* record field 7 means that return flows occur in the next month after the diversion. All rights may have access in priority order to the next-month return flow.

Since type 2 is entered in *WR* record field 6 for rights WR-15 and WR-24, the diversion target is met in each month first by available stream flow supplemented as necessary by reservoir releases. WR-24 is a type 2 diversion right at the Hempstead Gage control point (CP identifier Hemp) supplied by stream flow and releases from Possum Kingdom, Belton, Georgetown, and Granger Reservoirs. As type 2 rights, multiple-reservoir system water rights WR-15 and WR-24 do not refill reservoir storage. The reservoirs are refilled by the junior type 1 water rights WR-25, WR-26, WR-27, and WR-28.

For multiple-reservoir system rights WR-15 and WR-24, the release is made from the reservoir that is most full in terms of percentage of the active conservation pool capacity. The

active conservation storage capacity is the total capacity from *WS* record field 3 less the inactive capacity from *WS* record field 7. In a particular month of the simulation, if the contents of the active conservation pool of Belton, Georgetown, and Granger Reservoirs is 82%, 91%, and 87% of capacity, releases are made from Georgetown since 91% indicates it is most full. The operation rules *OR* record described in the *Reference* and *Users Manual*s provides greater flexibility in modeling more complex system operating rules.

SV/SA and PV/PE Record Tables in the SIM DAT File (pages 41 and 81)

Storage volume versus water surface area tables are provided on *SV/SA* records for each of the reservoirs. These tables are linearly interpolated to determine water surface areas corresponding to computed storage volumes for use in computing net evaporation volumes. *SV/SA* records must be provided if fields 4, 5, and 6 of the *WS* record for the reservoir are blank.

Hydropower right WR-4 requires a storage volume versus water surface elevation table provided on *PV/PE* records for Whitney Reservoir with identifier Whit for use in determining head in the hydropower computations. *PV/PE* records must be provided for any reservoir associated with a hydropower right as defined by type of 5 or 6 being entered in *WR* field 6.

FLO and EVA Input Files for Program SIM (pages 42-43 and 82)

The beginning of the FLO and EVA files are shown on pages 42 and 43, respectively. The FLO file contains the naturalized flows on inflow *IN* records. The EVA file contains the net evaporation less precipitation depths on *EV* records.

The parameter *INEV* in *JO* record field 2 specifies the file option and sequencing option used to compile the *IN* and *EV* records. Option 2 adopted for the example dataset has the *IN* records in a FLO file and *EV* records in an EVA file grouped by control point. The files begin with records for control point PK for all 58 years, followed by 58 records for control point Whit, followed by the 58 years of data for the next control point. The control points may be in any arbitrary order. The years 1940-1997 must be in chronological order.

The Texas WAM System datasets use the default *JO* field 2 *INEV* option 1 for sequencing records in the FLO and EVA files with grouping by year. The files begin with records for all control points for the first year. Since simulation computations are performed sequentially by month, the option of grouping by year allows storing only one year of naturalized flows and net evaporation depths in computer memory. Option 2 requires reading of all *IN* and *EV* records at the beginning of the simulation. Thus, option 1 is more efficient in use of computer memory. Program *HYD* includes routines for changing the sequencing of the *IN* and *EV* records in the *SIM* input files.

MSS Output File for Program SIM (page 44)

Model users should routinely check the message file. For this example, the message file contains only trace messages tracking reading of input data and initiation of the simulation. Errors or irregularities in input data may result in either error or warning messages being written

to the MSS file. Program execution is terminated along with an error message. A warning message indicates irregularities or possible problems without terminating execution. *SIM* contains a myriad of routines for checking input datasets. The *Users Manual* provides guidance for detecting and correcting problems in voluminous input datasets. Various other options not used in the example dataset may result in other information being written to the message file that is not related to checking for errors or problems.

OUT Output File for Program SIM (page 45-46)

Only the beginning of the lengthy *SIM* simulation results file is reproduced on pages 45-46. Time series variables written each month are listed in Table 3.2. Each output record for each month is associated with each *WR* record water right, *IF* record water right, control point, or reservoir. *JD* record fields 5 and 6 along with the *WO*, *GO*, *CO*, and *RO* records in the DAT file control the selection of water rights, control points, and reservoirs to include in the OUT file.

The OUT file format is designed to efficiently store voluminous simulation results. Model users typical do not read the OUT file. Rather, the program *TABLES* reads the *SIM* OUT file and organizes the simulation results in user-specified optional formats. The *TABLES* TIN input file and TAB output file are reproduced as Appendix B and discussed in the next chapter.

Yield-Reliability Analysis Option

An iterative routine to develop a yield versus reliability relationship is controlled with the firm yield *FY* record. The firm yield is the last entry in the resulting *SIM* yield-reliability table, assuming a non-zero firm yield is possible. The firm yield is the maximum value of a diversion or hydropower target that has a computed reliability of 100 percent. In some situations, any non-zero target results in a reliability of less than 100 percent. The yield-reliability analysis computations are based on an automated repetition of the entire simulation. One or more selected water rights start with a user-specified annual diversion or hydropower target that is iteratively reduced until either the firm yield or a zero target is reached.

The annual water supply diversion target or hydroelectric energy generation target is entered in field 3 of the *SIM* water right *WR* record. The reliabilities associated with various yields, represented by the annual target amount, may be developed simply by running *SIM* and *TABLES* multiple times, manually changing the target entry in *WR* record field 3 for each run. The option activated by the *FY* record automates this procedure. In a single *SIM* execution, multiple simulations are repeated with the annual target amount being systematically changed. The resulting yield-reliability table is written as a *SIM* output YRO file.

The diversion or hydropower yield may be associated with a single water right or a set of any number of rights. If associated with multiple water rights, two options are available for allocating the annual yield amount between rights. With the first option, the yield is allocated between rights in proportion to target amounts entered in field 3 of the water right *WR* records. The second option is based on the priorities from *WR* record field 7. The yield is assigned to the most senior priority right up to the target amount specified by its *WR* record. Any yield remaining is assigned to the next most senior priority right up to its target amount, and so forth.

Yield-Reliability Analysis Example

As previously discussed, the DAT file for the example is presented on pages 39-41. Activation of the iterative yield-reliability analysis option requires the addition of a *FY* record to the DAT file. The 14th record in the DAT file is a *FY* record that has been deactivated by conversion to a ** record. Removal of the ** activates the *FY* yield record and the iterative simulation algorithm that it controls. The results are written by *SIM* to the YRO file reproduced ed on page 47. The yield versus reliability table covers a range of diversion targets for water right WR-24. The estimated firm (100% reliability) yield is 303,900 acre-feet/year.

In the original dataset, the *WR* record for water right WR-24 has an annual diversion target of 900,000 acre-feet/year. With the *FY* record added, this target is replaced with the 1,200,000 ac-ft/yr from *FY* field 3. All other aspects of the simulation reflected in the input dataset in files Example.DAT, Example.FLO, and Example.EVA remain identically the same.

The results for the simulation with the 1,200,000 ac-ft/yr target is presented in the first line of the yield-reliability table on page 47. The mean actual annual diversion of 1,110,810 ac-ft/yr is 92.57% of the target. The target was met without shortage in 621 months or 89.22% of the 696 months in the simulation. Since shortages did occur, the simulation is repeated with a reduced target diversion amount for right WR-24. The incremental reductions in the diversion target are set by *FY* record fields 4, 5, and 6. The target is reduced by 100,000 ac-ft/yr increments (*FY* field 4) until the mean diversion shortage drops to below 0.05 ac-ft/yr or the target reduces to zero. The iterative process is then repeated for 10,000 ac-ft/yr increments (*FY* field 5) and then 1,000 ac-ft/yr (*FY* field 6) and 100 ac-ft/yr (10% of *FY* field 6) increments.

The parameter in *FY* record field 2 is the fraction (0.0 to 1.0) of the monthly target that must be met in order to not count the month as a failure in meeting the target in the period reliability computations. The blank *FY* field 2 in the example results in adoption of the default of 1.0. With an entry of 0.95 in field 2, the period reliability would be defined as the percentage of months during the simulation during which at least 95% of the diversion target was supplied. The *FY* field 2 parameter affects only the last two columns of the YRO file yield-reliability table.

Each of the 28 iterations reflected in the yield-reliability table is a complete 1940-1997 hydrologic period-of-analysis *SIM* simulation with all input the same except for the WR-24 diversion target. Iterations for each of the four levels of target increments stopped when the mean annual shortage dropped below 0.05 ac-ft/yr. The increment for the 4th level of target reductions is 100 ac-ft/yr, automatically set at 10 percent of the 1,000 ac-ft/yr entered in *FY* record field 6. The simulation results shown in the YRO table indicate that a WR-24 diversion target of 304,000 ac-ft/yr results in a mean shortage equaling or exceeding 0.05 ac-ft/yr. However, the mean shortage for a target of 303,900 ac-ft/yr is below this limit. The mean shortage is shown in the table to be 0.00 meaning it is something less than 0.005 ac-ft/yr. Non-zero shortages occur in three months resulting in a period reliability of 99.57 percent. The period reliability can be changed to 100.00% by entering 0.999 in *FY* record field 2.

CHAPTER 4
ORGANIZATION OF SIMULATION RESULTS WITH PROGRAM TABLES

The post-simulation program *TABLES* provides an array of tables and data tabulations in user-specified formats for organizing, summarizing, analyzing, and displaying *SIM* simulation results. *TABLES* reads the time series of monthly values of the simulation result variables listed in Table 3.2 and creates tables and data listings. *TABLES* also creates tables organizing and summarizing water rights data read from a *SIM* input file.

Some of the *TABLES* routines simply rearrange and tabulate, with appropriate table headings, selected data read from *SIM* input or output files. The various options provided by *TABLES* include rearranging simulation results as:

- convenient tables in a text file for reports and analyses
- tabulations in a text file to be read by Microsoft Excel
- records in a binary file to be read by HEC-DSSVue

Program *TABLES* also includes computational algorithms, which may range from simple sums or statistics to more complex arithmetic operations. A reliability table for water supply diversion or hydroelectric energy targets includes volume reliabilities and period reliabilities for meeting various percentages of the target demands. Frequency tables are developed for naturalized flows, regulated flows, unappropriated flows, reservoir storage, and instream flow shortages. Reservoir storage may be also displayed as comparative tabulations of storage contents as a percentage of capacity and drawdown-duration and storage-reliability tables.

Files and Input Records

The *TABLES* input TIN file specifies the tables and/or other types of information to be developed and stored in the *TABLES* output TAB file. The data from which the tables and data listings are compiled are read from *SIM* input and/or output files. Most applications involve *TABLES* reading simulation results from a *SIM* OUT file. However, various *TABLES* options activated by the records in the TIN file may involve reading data from the *SIM* DAT file as well.

Program *TABLES* consists of a main program and a number of subroutines. The main program opens files, checks the identifier on each record of the TIN file, and calls the appropriate subroutines. The *SIM* input and output files are read and the specified tables and data listings are developed and written to the *TABLES* output TAB file by the subroutines. Each subroutine is associated with specific types of tables or data listings and is activated by one or more types of input records read from the TIN file. The types of *TABLES* input records included in a TIN file are listed in Table 4.1 with the four-character identifiers that are placed at the beginning of each record. Explanations of each input record are provided as Appendix D. The records listed in Table 4.1 and Appendix D omit a number of the less frequently used tables covered in the *Users Manual*.

TABLES creates tables for user-specified water rights, groups of water rights, control points, or reservoir/hydropower projects. Selections may be specified by listing identifiers on the *TABLES* input records. Alternatively, the default often adopted is to include all water rights, control points, or reservoir/hydropower records in the *SIM* OUT file, as controlled by *SIM* input records.

Table 4.1
Types of *TABLES* Input Records

Miscellaneous Records

TITL – titles or headings
COMM or **** – comments
PAGE – title page
UNIT – units for table headings
TEST – checks of *SIM* output file
ENDF – end of input data file

Type 1 Records – Tables Developed from *SIM* Input File

1REC – listing of specified input records
1SUM – water rights summary by control point or type of use
1SRT – listing of water rights sorted by priority, type of use, control point, or water right type
1CPT – listing of control point information in upstream-to-downstream order

Type 2 Records – Tables Developed from *SIM* Output File

Time Series Tables in Optional Formats or HEC-DSS File

2NAT – naturalized stream flow
2REG – regulated stream flow
2UNA – unappropriated stream flow
2CLO – channel loss
2CLC – channel loss credits
2RFR – return flow entering at this control point
2URR – regulated flow at this control point from upstream reservoir releases
2STO – reservoir storage
2EVA – reservoir evaporation-precipitation volume
2EPD – reservoir evaporation-precipitation depth
2DEP – stream flow depletion
2TAR – diversion target
2SHT – diversion shortage
2DIV – diversion
2RFL – return flow
2ASF – available stream flow
2ROR – releases from other reservoirs
2IFT – instream flow target
2IFS – instream flow shortage
2HPS – hydropower shortage or secondary energy
2HPE – energy generated
2RID – inflows to reservoir from stream flow depletions
2RIR – inflows to reservoir from releases from other reservoirs
2RAH – releases accessible to hydropower
2RNA – releases not accessible to hydropower

Table 4.1 (Continued)
Types of *TABLES* Input Records

Reliability and Frequency Tables

2REL – reliability summary by control point, water right, water right group, or reservoir
2RET – composite volume reliability supplement to 2REL table
2FRE – frequency table for stream flow, storage, or instream flow shortage
2FRQ – frequency for specified stream flow, storage, or instream flow shortage
2RES – reservoir percentage of storage capacity, draw-down duration, and storage reliability

Summary Tables

2SCP – monthly or annual summary table for a control point
2SWR – monthly or annual summary table for a water right
2SRE – monthly or annual summary table for a reservoir
2SGP – monthly or annual summary table for a water right group
2SBA – monthly or annual summary table for the entire river basin

Reliability and Frequency Metrics

Simulation results are used in a variety of ways to develop an understanding of a river basin system. Alternative model runs demonstrate the effects of alternative water use scenarios and management strategies. Simulation results may be organized in various formats including: the entire time sequences of monthly values of various variables; annual summaries; period-of-analysis means; monthly, annual, or period-of-analysis water budgets; reliability indices; and frequency relationships. These forms of information may all be useful in analyzing, interpreting, and applying the results of a simulation study to support decision-making processes.

Concise measures of water availability/reliability are useful in analyzing and displaying simulation results. Program *TABLES* options include the following frequency statistics for concisely summarizing *WRAP-SIM* results:

- volume and period reliability tables for water supply diversion and hydroelectric energy generation targets (2REL record)
- frequency tables for naturalized, regulated, and unappropriated flows, reservoir storage, and instream flow shortages (2FREQ and 2FRQ records)
- reservoir drawdown-duration and storage-reliability tables (2RES record)

Volume and Period Reliability

The reliability summary created with a 2REL record may be for either water supply diversion or hydroelectric energy generation targets for individual water rights, the aggregation of all rights associated with individual reservoirs or control points, groups of selected rights, or

the aggregation of all rights in the model. The reliabilities or frequencies may be for an individual month of the year such as July or August or may reflect all months. *TABLES* computes both period reliabilities based on percent-of-time and volume reliabilities based on diversion volumes or hydroelectric energy production amounts.

Volume reliability is the percentage of the total target demand amount that is actually supplied. For water supply diversions, the amounts are volumes. For hydroelectric power, the amounts are kilowatt-hours of energy generated. Volume reliability (R_V) is the ratio of volume supplied or energy supplied (v) to the volume or energy target (V), converted to a percentage.

$$R_V = \frac{v}{V}(100\%) \tag{4.1}$$

Equivalently, for water supply, R_V is the mean actual diversion rate as a percentage of the mean target diversion rate. For hydropower, R_V is the mean actual rate of energy production as a percentage of the mean target energy production rate.

Period reliability is based on counting the number of periods of the simulation during which the specified demand target is either fully supplied or a specified percentage of the target is equaled or exceeded. A reliability summary includes tabulations of period reliabilities expressed both as the percentage of months and the percentage of years during the simulation during which water supply diversions or hydroelectric energy production equaled or exceeded specified magnitudes expressed as a percentage of the target demand. The various variations of period reliability (R_P) are computed by *TABLES* from the results of a *SIM* simulation as:

$$R_P = \frac{n}{N}(100\%) \tag{4.2}$$

where n denotes the number of periods during the simulation for which the specified percentage of the demand target is met, and N is the total number of periods considered. The *2REL* record allows N and n to be defined optionally either considering all months or only months with non-zero demand targets.

A *TABLES* reliability summary includes tabulations of period reliabilities expressed both as the percentage of months and the percentage of years during the simulation during which diversions (or energy produced) equaled or exceeded specified magnitudes expressed as a percentage of the target demand. For example, the standard reliability table shows the percentage of months in the simulation for which the computed diversion equals or exceeds 75% of the monthly diversion target. It also shows the percentage of years for which the total diversions during the year equal or exceed 75% of the annual permitted amount. The table also shows the percentage of months for which the demand is fully 100% met, without shortage, as well as reliabilities for several other percentages of the target.

Period reliability R_P is an expression of the percentage of time that the full demand target or a specified portion of the demand target can be supplied. Equivalently, R_P represents the likelihood or probability of the target being met in any randomly selected month or year.

Flow-Frequency and Storage-Frequency Relationships

Frequency tables created with *TABLES 2FRE* and *2FRQ* records may be developed for naturalized flow, regulated flow, unappropriated flow, and reservoir storage for specified control points and instream flow shortages and reservoir storage for specified water rights. Frequency tables may be for a specified month of the year such as November or for all months.

Exceedance frequency is defined as:

$$\text{Frequency} = \frac{n}{N} \ (100\%) \tag{4.3}$$

where n is the number of months during the simulation that a particular flow or storage amount is equaled or exceeded, and N is the total number of months in the simulation. The exceedance frequency is an expression of the percentage of time that particular flow or storage amounts can be expected to be equaled or exceeded. Equivalently, the exceedance frequency represents the likelihood or probability of a certain amount of water being available.

The *2FRE* table includes the mean and standard deviation, minimum and maximum, and the flow or storage amounts that are equaled or exceeded specified percentages of the time. For the specified fixed frequencies, *TABLES* sorts and searches the flow or storage data from the *SIM* simulation results to find a value that is equaled or exceeded during the specified percentage of the months of the simulation. If a single monthly flow value does not precisely match that frequency, linear interpolation is applied to the two flow values that bracket the specified frequency.

The *2FRQ* table also develops a flow-frequency, storage-frequency, or instream flow shortage-frequency relationship. However, the model-user enters selected flow or storage amounts of interest. *TABLES* simply counts the number of months for which a specified amount was equaled or exceeded and applies Equation 4.3 to assign a frequency.

Reservoir Storage Fluctuation Tables

The 2RES record develops three optional types of tables for analyzing reservoir storage fluctuations: (1) storage content as a percentage of capacity comparison, (2) drawdown-duration table, and (3) storage-frequency relationship. The tables may be for a particular month like June or for all months.

The first 2RES table is a tabulation of end-of-month storage content expressed as a percentage of the storage capacity of a user-specified zone. The storage content as a percentage is:

$$\text{storage content as percentage of capacity} = \frac{S - C_2}{C_1 - C_2}(100\%) \tag{4.4}$$

where S is the storage content volume and C_1 and C_2 are the user-specified total storage capacity below the water surface elevations defining the top and bottom of the storage zone or pool being

considered. Often, C_1 will be the total conservation storage capacity of the reservoir, and C_2 will be entered as zero. C_1 may be the total conservation capacity, and C_2 the inactive storage capacity. However, any zones of interest may be analyzed. The storage percentage is negative for a storage content less than C_2 and greater than 100% for a storage content greater than C_1.

Reservoir storage frequency tables based on Equation 4.3 may be developed with *TABLES* using the *2FRE* or *2FRQ* records for either water rights or control points. The *2RES* record provides two other alternative formats for this type of information. The *2RES* drawdown duration table shows the number of months of the simulation for which the end-of-month drawdown (storage depletion) exceeds given percentages of the storage capacity of a specified storage zone. Drawdowns are expressed as a percentage of storage capacity as follows.

$$\text{drawdown as percentage of capacity} = 100\% - \frac{S - C_2}{C_1 - C_2}(100\%) \qquad (4.5)$$

TABLES counts and tabulates the number of months during the simulation for which the drawdown defined by Equation 4.5 equals or exceeds 0%, 2%, 5%, 10%, 25%, 50%, 75%, 90%, and 100% of the storage capacity of the zone reflected in Equation 4.4.

The storage-reliability table displays the same information in a different format. The storage-reliability relationship is expressed in terms of the percentage of months for which the contents equaled or exceeded specified percentages of the pool capacity defined by Eq. 4.4.

Simulation Example

An example is presented in the previous Chapter 3. Program *TABLES* reads the *SIM* output file and constructs the tables presented in Appendix B. The tables are created in accordance with the specifications defined by the TIN file presented in Appendix B on page 49. The *TABLES* message TMS file is on page 50. The simulation results are in the TAB file reproduced on pages 51-64. The *TABLES* input records found in the *TABLES* input TIN file are described in Appendix D. Other types of *TABLES* input records not covered here can be found in the *Users Manual*. All *TABLES* TIN file input records are optional. Most contain a variety of options for building tables.

The TMS message file on page 50 contains only the trace of the *TABLES* execution. The absence of warning or error messages indicates that no irregularities or input errors were detected.

The PAGE record in the TIN file on page 49 creates the TAB file cover page shown as page 51. Comment records beginning with COMM, ****, or ** are not read by the computer. Comment records simply provide a means to document the TIN file. Records can also be temporarily deactivated by adding a ****. Records following the ENDF record also are not read by the computer. Model users may store alternative sets of records behind an ENDF record.

Time Series Tables (pages 49 and 86-88)

The 2NAT, 2REG, 2UNA, and 2IFS records in the TIN file on page 49 are examples of the 25 types of time series records listed on page 86 with fields defined on page 87-88. The time series

of simulation results for the variables listed in Table 3.2 on page 11 and in Appendix D on page 86 may be tabulated in the following alternative formats.

1. Tables with annual rows and monthly columns as illustrated by the 2NAT, 2REG, 2UNA, and 2IFS record tables shown on pages 52-55.

2. Each time series variable may be tabulated as a column as illustrated by the 2NAT, 2REG, 2UNA, and 2IFS record results on page 56. This format is designed for convenient conversion to a Microsoft Excel spreadsheet for plotting or further computations. Either monthly or annual values may be tabulated. A monthly tabulation would be 12 times as long as the annual tabulation shown on page 56.

3. A binary file with the filename extension DSS may be created with each monthly or annual time series variable of interest stored as a HEC-DSS record. This format allows the data to be read by *HEC-DSSVue* for plotting or further computations.

Frequency Tables (pages 57-58 and 91)

2FRE or 2FRQ record field 2 is a selection of different variables for which frequency tables may be created. The frequency tables for the example for naturalized, regulated, and unappropriated stream flows presented on page 57 are based on the data tabulated in the time series tables on pages 52-54. The frequency tables may reflect all 696 months of the 1940-1997 hydrologic simulation period or alternatively be limited to a particular month, such as the month of August during each of the 58 years. Storage-frequency tables are presented on page 58 alternatively for all 696 months and considering only the 58 August's (month 8).

As an example of reading the frequency tables, referring to the first line of the first table on page 58, end-of-month storage contents of Possum Kingdom Reservoir equaled or exceeded 553,931 acre-feet during 25 percent of the 696 months of the simulation. This can be interpreted as there being an estimated 0.25 probability that storage in Possum Kingdom Reservoir will be at or above 553,931 acre-feet at any randomly selected point in time based on all the premises reflected in the model. The second table on page 58 is for the month of August (month 8). End-of-August storage contents of Possum Kingdom Reservoir equaled or exceeded 495,300 acre-feet during 25 percent of the 58 years of the simulation. There is an estimated 0.25 probability that the storage in PK will be at or above 495,300 acre-feet at the end of August in any randomly selected year.

The three tables on page 57 and first two tables on page 58 were created with the 2FRE records shown on page 49. The values of the selected variable associate with fixed exceedance frequencies of 100%, 99%, 98%, 95%, 90%, 75%, 60%, 50%, 40%, 25%, 10% and 0% are tabulated. The last table on page 58 shows the alternative format of a frequency table created with a 2FRQ record.

The last frequency table on page 58 is for instream flow shortages for water right IF-2. The data are tabulated in the 2IFS record table on page 55. Instream flow shortage amounts of 1.0 ac-ft/month, 2,000 ac-ft/month, 4,000 ac-ft/month, 6,000 ac-ft/month, 8,000 ac-ft/month, 10,000 ac-ft/month, and 12,000 ac-ft/month are entered on the 2FRQ record shown

on page 49. The resulting table at the bottom of page 58 shows the frequencies at which these amounts are equaled or exceeded during the 696 month simulation.

Reliability Tables (pages 59-60 and 89-90)

An array of variations of reliability tables may be created. Reliability tables may be for either water supply diversions or hydropower production. Reliability tables for water supply diversions may be for either individual water rights, water right groups, totals of all water rights at each control point, or water rights aggregated by reservoir. Hydropower production reliability tables are typically by reservoir but can also be for either individual water rights or water right groups. Reliabilities may be computed considering all 12 months of the year or a selected individual month.

The 2REL records of the example *TABLES* input TIN file are shown on page 49. The content and format of each field of the 2REL record are explained on pages 89-90. The resulting tables written to the TAB file are on pages 59-60.

The first reliability table on page 59 is for aggregated water supply diversions at each control point. The diversion targets at the PK control point sum to a total of 254,800 ac-ft/yr. The mean shortage is 10,135.5 ac-ft/yr resulting in a volume reliability of 96.02 percent. The reliability table also shows the percentage of months and percentage of years during which specified percentages of the diversion target are equaled or exceeded. Diversion targets are fully met during 94.54 percent of the 696 months and 82.8 percent of the 58 years of the simulation. At least 75% of the total monthly target is supplied during 94.8 percent of the 696 months. At least 75% of the total annual target is supplied during 94.8 percent of the 58 years.

The second reliability table on page 59 is for individual water rights. Both tables on page 59 have the same format and reflect the same counting computations. The difference is that the diversion data is for individual water rights in the second table and for the sum of all water rights at each control point for the first table. If only one water right was assigned to each control point, the two tables on page 59 would be the same. However, the tables are different since 24 diversion rights are assigned to 11 control points.

The first reliability table on page 60 is similar to the last table on page 59. The difference is that the monthly data for the reliability table on page 60 considers only the month of August in each of the 58 years. The annual reliabilities on the right side of the table are based on the entire 12-month years and thus are not altered.

The middle table on page 60 is for hydroelectric power production. The 2REL record creating this record has the reservoir/hydropower option selected in field 4. This means that reservoir/hydropower output records were read by *TABLES* from the *SIM* OUT file. Hydropower production may also be included on water right output records. However, the −1 entered for the OUTWR parameter in *JD* record field 6 in the *SIM* DAT file excludes hydropower rights in the selection of rights to be included in the *SIM* OUT file. Reservoir/hydropower output records are included in the *SIM* OUT file in accordance with

the *RO* record. Although the hydropower right WR-4 could be easily included in the water right reliability tables on pages 59-60, mixing hydropower production in kilowatt-hours and diversions in acre-feet in the same tables is awkward and potentially confusing.

Optional water right group identifiers entered in *WR* record fields 12 and 13 in the DAT file may be used for various purposes. One use of these group identifiers is to group water rights in reliability tables. The last reliability table on page 60 is for water right groups. The diversions amounts are the totals for all water rights included in a particular group.

Reservoir Storage Tables (pages 61-62 and 92-93)

2RES records create three different types of tables as selected in 2RES field 2. These tables are illustrated on pages 61-62. The set of three 2RES records described on pages 92-93 is required to create either one, two, or all three of these tables.

The first four years of a 58 year table is reproduced on page 61. End-of-month reservoir storage in the active conservation pool is tabulated as a percentage of the storage capacity for each of the six reservoirs.

The reservoir storage duration table and reservoir storage reliability table on page 62 display the same type of information in different formats. The first table shows the number of months during the 696-month simulation during which the end-of-month storage draw-down equaled or exceeded specified percentages of the conservation storage zone defined by the formula on the top of page 61. The second table shows the percentage of the months during the 696-month simulation that the end-of-month storage equaled or exceeded specified percentages of the storage capacity of the defined storage zone.

Summary Tables (pages 63-64 and 94-95)

2SCP, 2SWR, 2SGP, 2SRE, and 2SBA records generate monthly or annual summary tables for control points, water rights, water right groups, or the entire river basin. An annual summary table for the Belton control point is presented on page 63. An annual summary table for the entire river basin is shown on page 64. Monthly tables would be 12 times as long with a line for each of 696 months rather than each of 58 years.

For an upstream control point such as the Belton gage control point, a water balance for a particular month, year, or entire 1940-1997 simulation can be expressed as follows:

$$\text{change in storage} = \text{naturalized stream flow} - \text{regulated stream flow} - \text{diversions} - \text{net evaporation} + \text{return flow}$$

Mean 1940-1997 and annual 1956 and 1957 values of these quantities from the summary table on page 63 are reproduced in Table 4.2.

Since no other control points are located upstream of the Belton control point, naturalized flows represent inflows to the control point. Regulated flows are the stream flows leaving the control point and flowing downstream. There are no return flows entering the

river at this control point. Water is removed through net evaporation and diversions. The change in reservoir storage in 1956 and 1957 is the difference in end-of-period (EOP) storage for the year and the previous year. For the 1940-1997 mean, the storage change of zero is the storage at the end of 1997 which happened to be 457,600 acre-feet minus the beginning of simulation storage which was also the capacity of 457,600 acre-feet, divided by 58 years.

Table 4.2 Water Budget for an Upstream Control Point

	Time Period		
Quantity	1940-1997	1956	1957
naturalized flows (acre-feet/year)	505,257	153,321	1,375,697
regulated flows (acre-feet/year)	323,615	56,418	748,378
net evaporation (acre-feet/year)	13,300	6,824	9,246
diversions (acre-feet/year)	168,342	90,079	160,472
storage change (acre-feet/year)	-0-	-0-	457,600

For the Belton Reservoir location and many other sites in Texas, 1956 is the driest year in the hydrologic period-of-analysis. The 1950-1957 drought was ended by one of the greatest floods on record in April-May 1957. Thus, these naturalized stream flow data illustrate the dramatic fluctuations in stream flow that may occur.

With no other control points located upstream, the Belton control point summary table contains all of the information needed for a complete water budget of inflows, outflows, and change in storage. However, the annual summary table for the entire basin does not contain enough information for a complete basin water budget. Information recorded in other tables regarding channel losses, channel loss credits, and negative incremental flow adjustments is also required for a complete water balance.

The diversion shortages in the last column of the summary tables on pages 63 and 64 are the diversion targets less the actual diversions. Shortages occur if water availability is inadequate to supply the full target demand. Stream flow depletions in the fourth column of the tables are the amounts of water appropriated to supply diversions and refill reservoir storage capacity that has been drawn-down over time by diversions, releases, and evaporation.

Unappropriated stream flow in the fifth column is the portion of the naturalized flow still remaining after considering all of the water rights in the dataset. For the Belton control point, the unappropropriated flow is less than the regulated flow because a portion of the stream flow at the Belton control point is committed to meet water right requirements at other control points located further downstream.

Appendix A − SIM Files for the Example

SIM DAT File

```
T1  File Example.DAT - WRAP-SIM Input Data File for the Example Dataset
T2  WRAP Fundamentals Manual
T3  April 2005
**
**-----!-------!-------!-------!-------!-------!-------!-------!-------!
** JD Record Fields
**  NYRS    YRST  ICHECK   CPOUT   OUTWR   IDSET  ADJINC
JD    58    1940       1      -1      -1               4
JO     2
**
**  Activation of the FY record results in a yield-reliability table being
**  developed and written to a file with the name Brazos.YRO.
**
**FY      1200000. 100000.  10000.   1000.   WR-24
**
RO    -1
**
**-----!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!
**       1         2         3         4         5         6         7         8         9         1
**34567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234
**-----!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!
**
**  Water Use Coefficient (UC) Records
**
UC  IND1   0.054   0.060   0.070   0.083   0.094   0.105   0.113   0.106   0.096   0.083   0.072   0.062
UC  IND2   0.058   0.077   0.087   0.097   0.107   0.124   0.128   0.124   0.078   0.041   0.038   0.041
UC  IRR1   0.005   0.007   0.017   0.033   0.092   0.163   0.267   0.235   0.117   0.044   0.014   0.007
UC  IRR2   0.005   0.008   0.018   0.032   0.075   0.189   0.304   0.253   0.079   0.022   0.008   0.007
UC  MUN1   0.065   0.063   0.068   0.072   0.085   0.093   0.118   0.114   0.095   0.087   0.071   0.069
UC  MUN2   0.065   0.063   0.066   0.069   0.082   0.105   0.111   0.106   0.100   0.089   0.074   0.069
UC POWER   2250.   2250.   2250.   2250.   2250.   3000.   6000.   6000.   3000.   2250.   2250.   2250.
**
**-----!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!
**
** Control Point (CP) Record Fields
**   2       3      4       5       6       7       8       9      10
** CPID1  CPID2   CPDT1   CPDT2  INMETH   CPIN    CPEV     EWA     CL
**-----!-------!-------!-------!-------!-------!-------!-------!-------!
**
CP    PK    Whit                                                  0.061
CP  Whit   WacoG                                                  0.009
CP WacoL   WacoG                                                  0.000
CP WacoG    High                                        none      0.010
CP  High   Bryan                                        none      0.014
CPBelton   Camer                                                  0.028
CPGeorge   Grang                                                  0.008
CP Grang   Camer                                                  0.015
CP Camer   Bryan                                        none      0.036
CP Bryan    Hemp                                        none      0.025
CP  Hemp                                                none
**
**-----!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!
**
** Water Right (WR and IF) Records and Reservoir Storage (WS) Records
** WR Record Fields
**    2       3       4       5    6   7       8    9      10      11              12
**   CP      AMT     USE   PRIOR            RFAC                 WRID            Group
**-----!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!
**
```

SIM DAT File (Continued)

```
**-----!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!
**
** Instream Flow Requirements at Cameron and Hempstead Gages  *!*******!*******!*******!
**
IF Camer   3600.   NDAYS       0               IF-1
IF  Hemp 120000.   NDAYS       0               IF-2
**
** Possum Kingdom Lake at Control Point PK  ***!*******!*******!*******!*******!*******!
**
WR    PK   9800.    MUN1  193804       2    0.35               WR-1            PK
WS    PK 570240.
WR    PK 245000.    IND1  193804                                WR-2            PK
WS    PK 570240.
**
** Whitney Lake at CP Whit     !*******!*******!*******!*******!*******!*******! *******!
**
WR  Whit  18000.    MUN1  198208       2    0.40               WR-3            Whitney
WS  Whit 627100.                        379000.
WR  Whit  36000.   POWER  999999   5   2                       WR-4            Whit HP
WS  Whit 627100.                        379000.
HP     0    440.    0.86
**
** Waco Lake at CP WacoL  *****!*******!*******!*******!*******!*******!*******!*******!
**
WR WacoL  59100.    MUN1  192901       2    0.35               WR-5            WacoLake
WS WacoL 104100.
WR WacoL    900.    IRR1  197902                                WR-6            WacoLake
WS WacoL 104100.
WR WacoL  20800.    MUN1  198609       2    0.40               WR-7            WacoLake
WS WacoL 192100.
**
**  Belton Lake at CP Belton  *!*******!*******!*******!*******!*******!*******!*******!
**
WRBelton  82760.    MUN1  196312       2    0.45               WR-8            Belton
WSBelton 457600.
WRBelton  97500.    IND1  196312       2    0.20               WR-9            Belton
WSBelton 457600.                           0
**
**  Georgetown Lake at CP George  *****!*******!*******!*******!*******!*******!*******!
**
WRGeorge  25610.    MUN2  196802       0    0.48               WR-10           George
WSGeorge  37100.
**
**  Granger  Lake at CP Grang  !*******!*******!*******!*******!*******!*******!*******!
**
WR Grang  42000.    MUN2  196802       0    0.40               WR-11           Granger
WS Grang  65500.
**
**  Cameron Gage - Run-of-River Diversion Rights  *****!*******!*******!*******!*******!
**
WR Camer  92100.    IRR2  198211       2    0.35               WR-12           Cameron
WR Camer  18200.    IND2  196105       2    0.50               WR-13           Cameron
WR Camer  11300.    IRR2  194510       2    0.10               WR-14           Cameron
**
**  Cameron Gage - Multiple-Reservoir System Diversion Right  *!*******!*******!*******!
**
WR Camer  88000.    MUN2  200601   2   2    0.35               WR-15           Cameron
WSBelton 457600.
WSGeorge  37100.
WS Grang  65500.
**
**  Waco Gage - Run-of-River Diversion Right  **!*******!*******!*******!*******!*******!
**
WR WacoG  32300.    IRR2  194607                                WR-16           WacoGage
**
```

SIM DAT File (Continued)

```
**  Highbank Gage - Run-of-River Diversion Right  *****!*******!*******!*******!*******!
**
WR  High  44800.    IRR2  195903                                WR-17           Highbank
**
**  Bryan Gage - Run-of-River Diversion Rights  *******!*******!*******!*******!*******!
**
WR Bryan  25400.    MUN2  198211       2    0.40               WR-18           Bryan
WR Bryan  39000.    IND2  196105       2    0.65               WR-19           Bryan
WR Bryan  34500.    IRR2  194510       2    0.05               WR-20           Bryan

**
**  Hempstead Gage - Run-of-River Diversion Rights  ***!*******!*******!*******!*******!
**
WR  Hemp  49600.    IRR2  194510                                WR-22           Hemp
WR  Hemp  95600.    IND2  196105                                WR-21           Hemp
WR  Hemp  74500.    IRR2  200601                                WR-23           Hemp
**
**  Hempstead Gage - Multiple-Reservoir System Diversion Right  *******!*******!*******!
**
WR  Hemp 900000.    MUN2  200601   2                           WR-24           Hemp
WS    PK 570240.
WSBelton 457600.
WSGeorge  37100.
WS Grang  65500.
**
**  Refilling Storage in Multiple-Reservoir System Reservoirs  !*******!*******!*******!
**
WR    PK                  999999                                WR-25           PK
WS    PK 570240.
WRBelton                  999999                                WR-26           Belton
WSBelton 457600.
WRGeorge                  999999                                WR-27           George
WSGeorge  37100.
WR Grang                  999999                                WR-28           Grang
WS Grang  65500.
**
**-----!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!
**       1         2         3         4         5         6         7         8         9         1
**3456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234
**-----!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!
**
**  Reservoir Storage Volume (acre-feet) versus Surface Area (acres) Tables
**
SVBelton      0.     40.    160.    650.   1100.   1800.  20900.  58700. 123500. 218100. 304170. 457600.
SA            0.     17.     32.     63.    110.    200.   1760.   3270.   5290.   7580.   9261.  12258.
**
SVGeorge      0.      3.     97.    280.    640.   1250.   2610.   4170.   6310.  11500.  22900.  37100.
SA            0.      2.     19.     45.     77.    130.    237.    323.    410.    620.    958.   1310.
**
SV Grang      0.     76.    272.    960.   2200.   3460.   5310.   7030.  10310.  23950.  46600.  65500.
SA            0.     16.     52.    180.    344.    500.    750.    980.   1230.   1828.   3280.   4400.
**
SV    PK      0.    236.    865.   3579.  10447.  22038.  25810. 147410. 298092. 504100. 547414. 724739.
SA            0.     60.    216.    525.    962.   1403.   1500.   5675.   9875.  14440.  15803.  19801.
**
SV WacoL      0.      8.     36.   1438.   3509.   4804.  17091.  29704. 105675. 304510. 517448. 828325.
SA            0.      4.     12.    160.    338.    562.   2741.   3524.   5986.  11049.  15517.  21388.
**
SV  Whit      0.      9.   1145.   4843.  51240. 157245. 379108. 427400. 559219. 1120975 1950148 2100400
SA            0.     22.    237.    507.   3210.   7500.  15760.  16450.  21740.  34920.  48960.  51190.
**
**  Reservoir Storage Volume (acre-feet) versus Elevation (feet) Table for Hydropower at Lake Whitney
**
PV  Whit   2630.  19600.  41710.  79990. 143200. 229400. 363600. 473100. 601800. 1970200
PE         448.8   470.0   480.0   490.0   500.0   510.0   520.0   527.0   533.0   571.0
**
**-----!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!-------!
ED
```

Beginning of SIM FLO File

```
**  File Example.FLO - Naturalized Flows in acre-feet/month for the Example Dataset
**
**    CP    Year     Jan     Feb     Mar     Apr     May     Jun     Jul     Aug     Sep     Oct     Nov     Dec
**
IN    PK    1940  10094.  10172.    836.  16772. 114403. 289797.  45691. 242432.  54126.   3317.  79433.  49363.
IN    PK    1941   9910.  75951.  64391. 201160.1267722. 627107. 140733. 116128. 103454. 758197. 137798.  43317.
IN    PK    1942  26025.  13531.  14131. 468326. 139111. 151003.  15609.  23207. 166710. 325061.  35589.  16542.
IN    PK    1943  16615.  10142.  26089.  57649.  17708.  70893.  14538.   1024.   1980.   2856.    802.    166.
IN    PK    1944   3922.  13485.  45426.  23584.  54063.  50477.  32829.  17198.  25757.  54397.  12288.  11908.
IN    PK    1945  11431.  12504. 119261.  98987.  28038.  42120. 151123.  12303.   6233.  94508.   6698.   1150.
IN    PK    1946  19379.  15155.   9356.   8718.  29334.  44444.  28702.  58775. 212225. 111731.  61578. 100854.
IN    PK    1947  13623.   6554.  12028.   8687. 479473.  54788.   8891.   2760.  13188.  34369.   9626.  37997.
IN    PK    1948   3748.   5871.  25281.   8583.  32120. 127828. 115435.  14256.   7234.  18154.  10575.   2927.
IN    PK    1949   2099.  12673.  13813.  15030. 320457. 176336.  16034.  15527.  93914.  63534.   9174.   2868.
IN    PK    1950   3037.   7982.   2631.  57812. 202611.  42025. 196046.  73270. 146770.  19577.    804.   1782.
IN    PK    1951   2761.   4274.   1833.   2048. 112117. 152042.  24098.  25353.  24699.      0.    348.      0.
IN    PK    1952  484.0    55.0   820.0  7073.0 16673.0 13986.0 14388.0  5388.0  5349.0  2645.0  4576.0  2382.0
IN    PK    1953   986.    576.   6662.   3116.  79575.      0. 265689.  89225.  17631. 252122.  25691.  10753.
IN    PK    1954   5182.   5221.   1602. 107969. 379232.  43287.  14581.  13551.    492.    539.  18851.      0.
IN    PK    1955   3906.   5662.  16837.  14931. 214934. 220077.  63325.  23962. 480744. 351752.  15346.   7815.
IN    PK    1956 15225.0  4032.0    23.0  2811.0 42134.0 14472.0     0.0     0.0  1468.0  6654.0 17993.0 20585.0
IN    PK    1957      0. 224472.   8925. 724847.1794495. 436949.  36297.  13320.  18908. 139484. 116312.  15332.
IN    PK    1958   9566.   7775.  35228.  64389. 216647.  32253. 208256.   8415.  60971.  10037.   2757.      0.
IN    PK    1959   1940.   1386.   2360.    293.  46332. 176976. 111079.  14016.   5523. 247161.   3430.  19495.
IN    PK    1960  45796.  35331.   9037.  22013.   6439.  13086. 201748.   9875.      0. 276670.  30007.  19004.
IN    PK    1961  44320.  34142.  23417.  10919.  28155. 272921. 249576.  24226.  71484.  12239.  33666.  11388.
IN    PK    1962   5357.   2918.   6050.   6906.   1965. 298988. 142004.  14825. 430354.  29743.  43409.  34142.
IN    PK    1963   5451.   6225.   8225. 101737.  98556. 209029.   1862.      0.   7862.  11866.  43033.   3851.
IN    PK    1964   7867.  45741.   7915.   4575.  12812.  33748.   3084.  16691.  43424.   5058.  64870.   2110.
IN    PK    1965   5258.   4967.   2753.  46413. 387943.  35922.   6551.  32331.  39812.  72654.   8707.   3327.
IN    PK    1966    244.   4735.   9563. 237550. 216184.  24612.   3806.  59066. 485457.  23755.   7052.   2802.
IN    PK    1967   3807.   5802.   8540.  54846.  25142. 105293. 164976.  15885.  53029.   7088.    200.   2797.
IN    PK    1968 261954.  43953. 159011. 118990.  71618.  91659.  63212.   9995.      0.      0.      0.   4969.
IN    PK    1969   3913.  11786.  80277.  68897. 479926.  36886.   1347.    949. 175947.  41054.  37679.  64380.
IN    PK    1970  26851.  22662.  97074.  63512. 105175.  18404.      0.      0.      0.      0.      0.      0.
IN    PK    1971   1139.   3007.   3146.   3892.  16938.  78061.   9211. 314526. 155232.  74358.  15352.  25431.
IN    PK    1972   5175.  11671.   7401.  15629.  73325.  19891.   9225. 172471. 113146.  47078. 152376.  19114.
IN    PK    1973  41253.  40138.  77266.  73590.  22940.  51406.  29617.  10070.  20393.  30462.   2692.      0.
IN    PK    1974   6198.   5824.   4714.  34603.  12562.  35083.   1810.  15255. 222780. 221348. 181421.  18757.
IN    PK    1975  30513.  97638.  28268.  27030. 112632. 110014.  57507.  41354.  37246.   5830.  11343.   6712.
IN    PK    1976   7548.   8493.   5107.  18254.  36498.   6133.  21751.  22568.  75235.  96050.  56332.   9625.
IN    PK    1977  12822.  13139.  69064.  62246.  67365.  42633.   8361.      0.   6149.      0.      0.   1634.
IN    PK    1978    217.   3801.  10109.  27861.  14393.  15249.    926. 758248.  33598.  17672.   7256.   3868.
IN    PK    1979   7244.   8608.  53583.  21763.  80955.  79809.  31312.  24895.   4048.   1933.      0.   4548.
IN    PK    1980   2709.   7432.   4084.   6158. 166079.  34913.   6775.   5405. 122743. 308062.  18514.  48318.
IN    PK    1981  16754.  13051.  43450.  81707.  34055. 134281.  12772.  12582.  10867. 823007.  23184.  11220.
IN    PK    1982   7437.  11680.  16168.   9818. 598989. 716459. 127253.  14071.   5822.   3824.   1133.   7055.
IN    PK    1983   7059.  17701.  16621.  10202.  89776.  40709.  10794.    248.      0.  96101.  33579.   8647.
IN    PK    1984  15485.  10450.   7204.   4653.   3202.      0.      0.   3839.   1228.  93904.  48426.  74734.
IN    PK    1985  83643.  73563.  78249. 108177. 124038. 124847.  27090.  12993.    427. 130355.  13138.   4705.
IN    PK    1986   8722.   7251.  10302.  15700.  27714. 162128.  76310.  18963. 127328. 408117.  77209.  63025.
IN    PK    1987  47547. 140041. 134879.  49645. 134543. 272034.  48889.   9791.  15841.   4837.   2719.  31817.
IN    PK    1988  14119.   9353.   8266.   7744.   8600.  19361.  28446.   5457.  58212.   6235.   2238.   5402.
IN    PK    1989   3098.  23293.  14416.   6076. 207439. 211760.   8463.  32413. 106998.   8585.   2681.   4384.
IN    PK    1990  13204.  21927. 154314. 542712. 551427. 247920.  16739.  47116. 110072.  21290.  19809.   7328.
IN    PK    1991  40465.  18738.  18532.  10796. 139094. 477467.  45420. 100033. 108629. 124704.  47890. 457156.
IN    PK    1992 151843. 510283. 291034.  74374.  91893. 490817.  82274.  42699.  25548.   4604.  16608.  24241.
IN    PK    1993  19433.  47772.  72569.  34691.  34035.  57103.   9967.  11573.  13666.  35937.   4741.   9819.
IN    PK    1994   6001.   8853.  10822.   6117. 310670.  22676.  18239.   8874.  19640.  75445.  40040.  12330.
IN    PK    1995   6976.   3101.  20209.  12666.  38307.  89490.  19971. 129594.  40225.   9864.   2817.   2385.
IN    PK    1996   3340.   8360.   7626.  17062.   7482.  15347.   6883.  43854. 236297.  35556.  45467.  35626.
IN    PK    1997  11489. 191297.  88264.  66212. 106436. 151162.  52841.  19651.   2874.   2543.      0.  14511.
IN  Whit    1940  11746.   6676.   4427.  41228. 131761. 354218. 100957. 267803.  68217.   9062. 266476. 197232.
IN  Whit    1941  58622. 282131. 165165. 292832.1327583. 773405. 213978. 214894. 107647. 702082. 228190.  46163.
IN  Whit    1942  41448.  21676.  19705. 917367. 440331. 374403.  33475.  36487. 205042. 461503.  69667.  38560.
IN  Whit    1943  22374.  25946.  65390.  85320.  52235.  95592.  14821.   3358.  16140.   5343.   2188.   5095.
IN  Whit    1944  15463.  52180. 104269.  42860. 322738.  76923.  43877.  18260.  68138.  58884.  25275.  30329.
IN  Whit    1945  62140. 177421. 358784. 412950.  82789.  86820. 278759.  24987.  14612. 173287.  15092.  10735.
```

Beginning of SIM EVA File

```
**  File Example.EVA - Net Evaporation-Precipitation Depths in feet/month for the Example Dataset
**
**    CP    Year     Jan      Feb      Mar      Apr      May      Jun      Jul      Aug      Sep      Oct      Nov      Dec
**
EV    PK    1940   0.159    0.055    0.459    0.191    0.266    0.106    0.834    0.524    0.651    0.536   -0.149   -0.014
EV    PK    1941   0.134   -0.161    0.179    0.011   -0.028    0.079    0.519    0.340    0.485   -0.199    0.316    0.165
EV    PK    1942   0.221    0.251    0.380   -0.380    0.247    0.361    0.800    0.597    0.226   -0.069    0.388    0.044
EV    PK    1943   0.225    0.325    0.116    0.394    0.275    0.490    0.761    1.038    0.587    0.498    0.370   -0.029
EV    PK    1944  -0.019   -0.067    0.226    0.357    0.212    0.711    0.702    0.773    0.614    0.345    0.112    0.028
EV    PK    1945   0.094   -0.032   -0.008    0.109    0.578    0.527    0.388    0.813    0.593    0.205    0.425    0.250
EV    PK    1946  -0.025    0.136    0.258    0.372    0.246    0.570    0.998    0.871    0.153    0.396    0.074    0.039
EV    PK    1947   0.114    0.247    0.112    0.122    0.082    0.679    0.969    0.901    0.877    0.438    0.202    0.009
EV    PK    1948   0.141   -0.038    0.271    0.434    0.252    0.428    0.684    0.896    0.820    0.526    0.451    0.309
EV    PK    1949  -0.170   -0.020    0.146    0.112   -0.135    0.377    0.806    0.593    0.454    0.074    0.442    0.121
EV    PK    1950   0.090    0.150    0.493    0.148    0.052    0.482    0.116    0.622    0.247    0.652    0.550    0.301
EV    PK    1951   0.209    0.069    0.291    0.298    0.043    0.115    0.728    0.835    0.672    0.444    0.247    0.271
EV    PK    1952   0.212    0.229    0.238    0.138    0.177    0.815    0.876    1.284    0.867    0.820    0.130    0.119
EV    PK    1953   0.230    0.188    0.177    0.264    0.252    0.946    0.608    0.658    0.794    0.015    0.195    0.250
EV    PK    1954  -0.003    0.328    0.381    0.062   -0.019    0.594    0.714    0.777    0.630    0.316    0.127    0.122
EV    PK    1955   0.031    0.089    0.207    0.337   -0.033    0.222    0.594    0.548    0.074    0.382    0.286    0.176
EV    PK    1956   0.044    0.046    0.401    0.361    0.162    0.653    0.807    0.780    0.707    0.291    0.195    0.023
EV    PK    1957   0.093   -0.106    0.114   -0.543   -0.709    0.259    0.529    0.649    0.244   -0.117   -0.222    0.144
EV    PK    1958  -0.006    0.070   -0.035   -0.039    0.052    0.453    0.283    0.464    0.118    0.205    0.153    0.087
EV    PK    1959   0.141    0.117    0.367    0.283    0.122   -0.102    0.189    0.476    0.342   -0.310    0.215   -0.030
EV    PK    1960  -0.051    0.061    0.144    0.248    0.237    0.510    0.283    0.387    0.284    0.053    0.286   -0.077
EV    PK    1961  -0.177    0.004    0.134    0.381    0.263   -0.082    0.176    0.474    0.130    0.160   -0.050    0.042
EV    PK    1962   0.140    0.202    0.164    0.031    0.365   -0.106   -0.003    0.389   -0.311    0.080    0.015    0.056
EV    PK    1963   0.114    0.129    0.226    0.070   -0.020    0.239    0.498    0.350    0.205    0.243   -0.047    0.072
EV    PK    1964  -0.009    0.051    0.257    0.257    0.162    0.584    0.808    0.416   -0.010    0.296   -0.130    0.158
EV    PK    1965   0.018    0.030    0.221    0.224   -0.244    0.449    0.802    0.469    0.346    0.132    0.204    0.093
EV    PK    1966   0.017    0.032    0.367   -0.138    0.279    0.356    0.651    0.121   -0.196    0.352    0.338    0.170
EV    PK    1967   0.249    0.233    0.406    0.230    0.198    0.457    0.401    0.712   -0.054    0.295    0.114    0.064
EV    PK    1968  -0.421    0.010   -0.055    0.142    0.004    0.300    0.294    0.549    0.343    0.363   -0.074    0.164
EV    PK    1969   0.139   -0.013   -0.104    0.068    0.036    0.395    0.713    0.274    0.011    0.012    0.189   -0.127
EV    PK    1970   0.148   -0.062   -0.008    0.099    0.229    0.579    0.750    0.546    0.142    0.239    0.355    0.273
EV    PK    1971   0.248    0.218    0.498    0.438    0.235    0.584    0.511    0.094    0.079   -0.013    0.190   -0.094
EV    PK    1972   0.131    0.201    0.466    0.303    0.143    0.471    0.555    0.405    0.240   -0.035    0.122    0.183
EV    PK    1973  -0.130    0.033    0.175   -0.032    0.336    0.238    0.218    0.587    0.002   -0.087    0.186    0.255
EV    PK    1974   0.139    0.225    0.335    0.345    0.352    0.552    0.647    0.175   -0.185   -0.166    0.125    0.034
EV    PK    1975   0.090   -0.011    0.216    0.195   -0.231    0.357    0.319    0.443    0.290    0.455    0.237    0.083
EV    PK    1976   0.252    0.351    0.371   -0.006    0.110    0.413    0.244    0.512    0.012   -0.173    0.145    0.100
EV    PK    1977  -0.052    0.173    0.075    0.101    0.075    0.493    0.629    0.431    0.577    0.368    0.194    0.311
EV    PK    1978   0.071   -0.070    0.244    0.339    0.175    0.511    0.779    0.283    0.286    0.357   -0.023    0.206
EV    PK    1979  -0.070    0.060    0.011    0.150   -0.032    0.319    0.452    0.328    0.481    0.438    0.205   -0.052
EV    PK    1980   0.041    0.108    0.303    0.407   -0.136    0.633    0.886    0.742   -0.072    0.334    0.130    0.029
EV    PK    1981   0.161    0.115    0.065    0.220    0.183    0.101    0.626    0.502    0.303   -0.766    0.177    0.183
EV    PK    1982   0.098    0.049    0.190    0.282   -0.496   -0.087    0.463    0.590    0.467    0.291    0.029    0.016
EV    PK    1983   0.026    0.065    0.020    0.334   -0.023    0.230    0.619    0.590    0.554    0.165    0.178    0.081
EV    PK    1984   0.170    0.197    0.142    0.492    0.426    0.488    0.627    0.535    0.445   -0.369    0.084   -0.279
EV    PK    1985   0.085   -0.007   -0.062    0.210    0.242    0.177    0.510    0.662    0.328   -0.067    0.106    0.148
EV    PK    1986   0.266    0.033    0.315    0.215   -0.076   -0.030    0.645    0.484    0.150   -0.108   -0.026   -0.090
EV    PK    1987   0.038   -0.206    0.196    0.409   -0.220    0.099    0.564    0.467    0.261    0.416    0.121   -0.114
EV    PK    1988   0.130    0.190    0.295    0.329    0.325    0.209    0.407    0.556    0.187    0.316    0.287    0.089
EV    PK    1989   0.064   -0.122    0.173    0.358   -0.232   -0.096    0.545    0.224    0.110    0.404    0.320    0.232
EV    PK    1990   0.023   -0.122   -0.128   -0.397    0.062    0.611    0.327    0.326    0.168    0.271   -0.041    0.063
EV    PK    1991  -0.091    0.196    0.344    0.366    0.218    0.148    0.630    0.328    0.136    0.044    0.225   -0.348
EV    PK    1992  -0.047   -0.057    0.198    0.279   -0.111    0.091    0.459    0.378    0.259    0.403   -0.040   -0.011
EV    PK    1993   0.009   -0.061    0.123    0.210    0.227    0.320    0.985    0.715    0.288    0.001    0.218    0.015
EV    PK    1994   0.075    0.029    0.278    0.174   -0.126    0.647    0.499    0.747    0.274   -0.144   -0.046    0.027
EV    PK    1995   0.000    0.000    0.039    0.203   -0.095    0.219    0.316    0.184    0.064    0.427    0.228    0.161
EV    PK    1996   0.176    0.301    0.257    0.365    0.413    0.349    0.463   -0.033   -0.119    0.179   -0.306    0.114
EV    PK    1997   0.264   -0.329    0.203   -0.023    0.050    0.061    0.537    0.386    0.485    0.109    0.154   -0.169
EV  Whit    1940   0.077   -0.011    0.324   -0.070    0.164    0.021    0.425    0.615    0.628    0.382   -0.438   -0.133
EV  Whit    1941   0.089   -0.151    0.047   -0.028    0.097   -0.029    0.434    0.426    0.526   -0.011    0.246    0.050
EV  Whit    1942   0.182    0.153    0.291   -0.476    0.058    0.223    0.615    0.397    0.143    0.055    0.218    0.036
EV  Whit    1943   0.165    0.275    0.075    0.287    0.013    0.348    0.572    0.809    0.293    0.330    0.277   -0.059
EV  Whit    1944  -0.140   -0.162    0.062    0.152   -0.375    0.529    0.630    0.586    0.549    0.444   -0.048   -0.060
EV  Whit    1945   0.009   -0.204   -0.275   -0.131    0.348    0.135    0.278    0.420    0.596    0.161    0.267    0.102
```

SIM MSS File

```
 WRAP-SIM MESSAGE FILE

*** Starting to read file Example.DAT
*** JD record was read.
*** JO record was read.
*** Reading RO record.
*** Starting to read UC records.
*** Finished reading UC records.
*** Starting to read CP records.
*** Finished reading CP records.
*** Starting to read IF/WR records.
*** Finished reading IF/WR records.
*** Starting to read SV/SA records.
*** Finished reading SV/SA records.
*** Starting to read PV/PE records.
*** Finished reading PV/PE records.
*** Finished reading file Brazos.DAT
*** Starting to open remaining files.
*** Opened file Example.FLO
*** Opened file Example.EVA
*** Opened file Example.OUT
*** Opened file Example.YRO
*** Finished opening files.
*** Starting to read IN and EV records.
*** All IN and EV records were read.
*** Finished ranking water rights in priority order.

*****************************************************
 System components counted from input file:
     11 control points (CP records)
      2 instream flow rights (IF records)
     28 all water rights except IF rights (WR records)
      3 system water rights
      1 hydropower rights
      7 sets of water use coefficients (UC records)
      6 reservoirs
      6 storage-area tables (SV/SA records)
      1 storage-elevation tables (PV/PE records)
*****************************************************

*** Beginning annual loop.
*** Negative incremental flow adjustments were performed for the first year.
*** End of input data trace.

 ***** Normal Completion of Program WRAP-SIM *****
```

Beginning of SIM OUT File

```
Program WRAP-SIM (April 2005 Version) Output File
  File Example.DAT - WRAP-SIM Input Data File for the Example Dataset
  WRAP Fundamentals Manual
  April 2005
  1940    58    11    29     6     0     0
IF   1      0.0      0.0      0.0      0.0      0.0      0.0      0.0           IF-1  333.13    0.00
IF   1      0.0      0.0      0.0      0.0      0.0      0.0      0.0           IF-2 11104.5  1111.5
1940 1    0.000 3841.500    629.3 100795.2   1166.0    1166.0      0.0           WR-5WacoLake          1344.5
1940 1    0.000  637.000   2594.5 570240.0   3231.5   10094.0      0.0           WR-1      PK          222.9
1940 1    0.00013256.514   2583.1 563857.4   6862.5    6862.5      0.0           WR-2      PK            0.0
1940 1    0.000   56.500      0.0      0.0     56.5    3892.9      0.0          WR-14 Cameron           5.7
1940 1    0.000  172.500      0.0      0.0    172.5   10306.5      0.0          WR-20   Bryan           8.6
1940 1    0.000  248.000      0.0      0.0    248.0   10273.9      0.0          WR-22    Hemp           0.0
1940 1    0.000  161.500      0.0      0.0    161.5    2952.0      0.0          WR-16WacoGage           0.0
1940 1    0.000  224.000      0.0      0.0    224.0    4140.7      0.0          WR-17Highbank           0.0
1940 1    0.000 1055.600      0.0      0.0   1055.6    3836.4      0.0          WR-13 Cameron         527.8
1940 1    0.000 2262.000      0.0      0.0   2262.0    8737.9      0.0          WR-19   Bryan        1470.3
1940 1    0.000 5544.800      0.0      0.0   5544.8    6459.2      0.0          WR-21    Hemp           0.0
1940 1    0.000 5379.400   1147.2 452069.4    996.0     996.0      0.0           WR-8  Belton        2420.7
1940 1    0.000 5275.551   1142.3 446798.7      0.0       0.0      0.0           WR-9  Belton        1055.1
1940 1    0.000 1666.316    133.9  35304.7      4.9       4.9      0.0          WR-10  George         799.8
1940 1    0.000 2732.733    420.0  63147.1    799.8     799.8      0.0          WR-11 Granger         1093.1
1940 1    0.000    4.496    629.3 100790.7      0.0       0.0      0.0           WR-6WacoLake            0.0
1940 1    0.000 1170.000   1794.9 625224.4   1089.3    1089.3      0.0           WR-3 Whitney          468.0
1940 1  460.500  460.500      0.0      0.0      0.0       0.0      0.0          WR-12 Cameron           0.0
1940 1 1652.653 1652.653      0.0      0.0      0.0       0.0      0.0          WR-18   Bryan           0.0
1940 1    0.000 1352.000    869.3 187198.7      0.0       0.0      0.0           WR-7WacoLake          540.8
1940 1    0.000 5725.726      0.0      0.0      0.0       0.0   5725.7          WR-15 Cameron         2004.0
1940 1  372.500  372.500      0.0      0.0      0.0       0.0      0.0          WR-23    Hemp           0.0
1940 1    0.00058558.559      0.0      0.0      0.0       0.0  58558.6          WR-24    Hemp           0.0
1940 1    0.000    0.000   2434.3 497886.0      0.0       0.0      0.0          WR-25      PK           0.0
1940 1    0.000    0.000   1136.9 440913.4      0.0       0.0      0.0          WR-26  Belton           0.0
1940 1    0.000    0.000    133.9  35304.7      0.0       0.0      0.0          WR-27  George           0.0
1940 1    0.000    0.000    420.0  63147.1      0.0       0.0      0.0          WR-28   Grang           0.0
    PK    0.00013893.514   2434.3 497886.0  10094.0       0.0      0.0   10094.0   66120.2   616. 4033. 66120.
  Whit    0.000 1170.000   1796.0 626401.8   2267.7       0.0      0.0   11746.0   62086.9   106.  559. 62087.
 WacoL    0.000 5197.995    869.3 187198.7   1166.0       0.0      0.0    1166.0       0.0     0.    0.     0.
 WacoG    0.000  161.500      0.0      0.0    161.5       0.0      0.0   13511.0   62071.3   130.  615. 61528.
  High    0.000  224.000      0.0      0.0    224.0       0.0      0.0   14754.0   62604.7   183.  853. 60913.
Belton    0.00010654.951   1136.9 440913.4   996.0       0.0      0.0     996.0    5890.7    28.  165.  5891.
George    0.000 1666.316    133.9  35304.7      4.9       0.0      0.0     156.0     151.1     0.    0.     0.
 Grang    0.000 2732.733    420.0  63147.1    799.8       0.0    799.8     502.0     497.1    12.   12.     0.
 Camer  460.500 7298.326      0.0      0.0   1112.1       0.0   1093.1    4226.0    3234.1   103.   68.     0.
 Bryan 1652.653 4087.153      0.0      0.0   2434.5       0.0      0.0   20668.0   64458.1   452. 1547. 60060.
  Hemp  372.50064723.859      0.0      0.0   5792.8       0.0      0.0   31649.0    9993.0     0.    0.     0.
    PK      0.0      0.0   2434.3 497886.0  10094.0       0.0  80013.8       0.0   0.15900
  Whit  -3817.2   6067.2   1796.0 626401.8   2267.7       0.0   1170.0       0.0   0.07700
 WacoL      0.0      0.0    869.3 187198.7   1166.0       0.0   5198.0       0.0   0.10700
Belton      0.0      0.0   1136.9 440913.4    996.0       0.0  16545.6       0.0   0.09400
George      0.0      0.0    133.9  35304.7      4.9       0.0   1666.3       0.0   0.10400
 Grang      0.0      0.0    420.0  63147.1    799.8       0.0   2732.7       0.0   0.09700
IF   2      0.0      0.0      0.0      0.0      0.0       0.0      0.0           IF-1  300.90    0.00
IF   2      0.0      0.0      0.0      0.0      0.0       0.0      0.0           IF-2 10029.9     0.0
1940 2    0.000 3723.300     41.3 101650.4   1315.0    1315.0      0.0           WR-5WacoLake          1303.2
1940 2    0.000  617.400    792.6 506647.9  10172.0   10172.0      0.0           WR-1      PK          216.1
1940 2    0.00014729.459    783.0 491928.1      0.0       0.0      0.0           WR-2      PK            0.0
1940 2    0.000   90.400      0.0      0.0     90.4   24764.9      0.0          WR-14 Cameron           9.0
1940 2    0.000  276.000      0.0      0.0    276.0   38653.5      0.0          WR-20   Bryan          13.8
1940 2    0.000  396.800      0.0      0.0    396.8  138277.8      0.0          WR-22    Hemp           0.0
1940 2    0.000  258.400      0.0      0.0    258.4     544.7      0.0          WR-16WacoGage           0.0
1940 2    0.000  358.400      0.0      0.0    358.4    6411.0      0.0          WR-17Highbank           0.0
1940 2    0.000 1401.400      0.0      0.0   1401.4   24674.5      0.0          WR-13 Cameron         700.7
1940 2    0.000 3003.000      0.0      0.0   3003.0   36421.0      0.0          WR-19   Bryan        1951.9
1940 2    0.000 7361.200      0.0      0.0   7361.2  133045.4      0.0          WR-21    Hemp           0.0
1940 2    0.000 5213.880   -523.7 437886.3   1663.0    1663.0      0.0           WR-8  Belton        2346.2
1940 2    0.000 5861.723   -521.2 432022.0      0.0       0.0      0.0           WR-9  Belton        1172.3
1940 2    0.000 1615.045   -113.7  35123.3   1320.0    1320.0      0.0          WR-10  George         775.2
1940 2    0.000 2648.649   -521.2  64734.4   3714.8    3714.8      0.0          WR-11 Granger         1059.5
```

Beginning of SIM OUT File (Continued)

```
1940 2    0.000    6.294    41.3 101644.1      0.0       0.0      0.0           WR-6WacoLake            0.0
1940 2    0.000 1134.000  -256.4 625524.1      0.0       0.0      0.0           WR-3 Whitney          453.6
1940 2    0.000  736.800     0.0      0.0    736.8   18530.9      0.0          WR-12 Cameron          257.9
1940 2    0.000 1601.802     0.0      0.0   1601.8   28136.2      0.0          WR-18   Bryan          640.7
1940 2    0.000 1310.400    56.1 183417.6      0.0       0.0      0.0           WR-7WacoLake          524.2
1940 2    0.000 5549.549     0.0      0.0   5549.5   17794.1      0.0          WR-15 Cameron         1942.3
1940 2    0.000  596.000     0.0      0.0    596.0  113756.7      0.0          WR-23    Hemp            0.0
1940 2    0.00056756.758     0.0      0.0  56756.8  113160.7      0.0          WR-24    Hemp            0.0
1940 2    0.000    0.000   783.0 491928.1      0.0       0.0      0.0          WR-25      PK            0.0
1940 2    0.000    0.000  -521.2 432022.0      0.0       0.0      0.0          WR-26  Belton            0.0
1940 2    0.000    0.000  -113.7  35123.3      0.0       0.0      0.0          WR-27  George            0.0
1940 2    0.000    0.000  -521.2  64734.4      0.0       0.0      0.0          WR-28   Grang            0.0
   PK     0.00015346.859   783.0 491928.1  10172.0       0.0      0.0   10172.0      0.0   620.    0.     0.
 Whit     0.000 1134.000  -253.6 603960.3      0.0       0.0    222.9    6676.0      0.0    86.    2.     0.
WacoL     0.000 5039.994    56.1 183417.6   1315.0       0.0      0.0    1315.0      0.0     0.    0.     0.
WacoG     0.000  258.400     0.0      0.0    258.4     286.3   2353.3    8751.0    286.3   110.   26.     0.
 High     0.000  358.400     0.0      0.0    358.4    6052.6      0.0   14791.0   6052.6   158.   36.     0.
Belton    0.00011075.604  -521.2 432022.0   1663.0       0.0      0.0    1663.0      0.0    47.    0.     0.
George    0.000 1615.045  -113.7  35123.3   1320.0       0.0      0.0    1320.0      0.0    11.    0.     0.
 Grang    0.000 2648.649  -521.2  64734.4   3714.8       0.0    775.2    4249.0      0.0    75.   12.     0.
 Camer    0.000 7778.149     0.0      0.0   7778.1   12244.6   4535.3   21590.0   12545.4   516.  191.     0.
 Bryan    0.000 4880.802     0.0      0.0   4880.8   21184.6   2537.5   40863.0   21184.6   746.  254.     0.
  Hemp    0.00065110.758     0.0      0.0  65110.8   56404.0   1478.9  149252.0   66433.8     0.    0.     0.
   PK       0.0      0.0   783.0 491928.1  10172.0       0.0  15346.9       0.0   0.05500
 Whit       0.0   2250.0  -253.6 603960.3      0.0       0.0  22695.0       0.0  -0.01100
WacoL       0.0      0.0    56.1 183417.6   1315.0       0.0   5040.0       0.0   0.00700
Belton      0.0      0.0  -521.2 432022.0   1663.0       0.0  11075.6       0.0  -0.04400
George      0.0      0.0  -113.7  35123.3   1320.0       0.0   1615.0       0.0  -0.09000
 Grang      0.0      0.0  -521.2  64734.4   3714.8       0.0   2648.6       0.0  -0.12100
IF   3      0.0      0.0     0.0      0.0      0.0       0.0      0.0            IF-1  333.13    0.00
IF   3      0.0      0.0     0.0      0.0      0.0       0.0      0.0            IF-2 11104.5     0.0
1940 3    0.000 4018.800  1979.6  99283.6   1182.0    1182.0      0.0           WR-5WacoLake          1406.6
1940 3    0.000  666.400  6472.1 485625.6    836.0     836.0      0.0           WR-1      PK          233.2
1940 3    0.00017184.369  6385.2 468528.2      0.0       0.0      0.0           WR-2      PK            0.0
1940 3    0.000  203.400     0.0      0.0    203.4    8443.5      0.0          WR-14 Cameron           20.3
1940 3    0.000  621.000     0.0      0.0    621.0   46420.7      0.0          WR-20   Bryan           31.1
1940 3    0.000  892.800     0.0      0.0    892.8   45574.4      0.0          WR-22    Hemp            0.0
1940 3    0.000  581.400     0.0      0.0    581.4   28407.1      0.0          WR-16WacoGage           0.0
1940 3    0.000  806.400     0.0      0.0    806.4   29923.6      0.0          WR-17Highbank           0.0
1940 3    0.000 1583.400     0.0      0.0   1583.4    8240.1      0.0          WR-13 Cameron         791.7
1940 3    0.000 3393.000     0.0      0.0   3393.0   42910.7      0.0          WR-19   Bryan        2205.4
1940 3    0.000 8317.200     0.0      0.0   8317.2   38556.6      0.0          WR-21    Hemp            0.0
1940 3    0.000 5627.680  2688.0 424695.4    989.0     989.0      0.0           WR-8  Belton          2532.5
1940 3    0.000 6838.677  2672.6 417872.0      0.0       0.0      0.0           WR-9  Belton          1367.7
1940 3    0.000 1691.952   254.7  33640.6    464.0     464.0      0.0          WR-10  George          812.1
1940 3    0.000 2774.775   980.0  62824.5   1844.8    1844.8      0.0          WR-11 Granger         1109.9
1940 3    0.000   15.285  1979.6  99268.4      0.0       0.0      0.0           WR-6WacoLake            0.0
1940 3    0.000 1224.000  7365.9 599228.5   3858.1    3858.1      0.0           WR-3 Whitney          489.6
1940 3    0.000 1657.800     0.0      0.0   1657.8    5334.7      0.0          WR-12 Cameron          580.2
1940 3    0.000 1678.078     0.0      0.0   1678.1   24410.1      0.0          WR-18   Bryan          671.2
1940 3    0.000 1414.400  2662.6 176488.6      0.0       0.0      0.0           WR-7WacoLake          565.8
1940 3    0.000 5813.813     0.0      0.0   3676.9    3676.9   2137.0          WR-15 Cameron         2034.8
1940 3    0.000 1341.000     0.0      0.0   1341.0   18707.8      0.0          WR-23    Hemp            0.0
1940 3    0.00059459.457     0.0      0.0  17366.8   17366.8  42092.6          WR-24    Hemp            0.0
1940 3    0.000    0.000  6385.2 468528.2      0.0       0.0      0.0          WR-25      PK            0.0
1940 3    0.000    0.000  2672.6 417872.0      0.0       0.0      0.0          WR-26  Belton            0.0
1940 3    0.000    0.000   254.7  33640.6      0.0       0.0      0.0          WR-27  George            0.0
1940 3    0.000    0.000   662.6  15506.2      0.0       0.0      0.0          WR-28   Grang            0.0
   PK     0.00017850.770  6385.2 468528.2    836.0       0.0      0.0    836.0      0.0    51.    0.     0.
 Whit     0.000 1224.000  7280.5 576762.5   3858.1       0.0    216.1    4427.0      0.0    42.    2.     0.
WacoL     0.000 5448.485  2662.6 176488.6   1182.0       0.0      0.0    1182.0      0.0     0.    0.     0.
WacoG     0.000  581.400     0.0      0.0    581.4       0.0  23841.9    6311.0   24002.4    64.  241.     0.
 High     0.000  806.400     0.0      0.0    806.4       0.0      0.0    8624.0   25332.0   100.  333.     0.
Belton    0.00012466.357  2672.6 417872.0    989.0       0.0      0.0     989.0      0.0    28.    0.     0.
George    0.000 1691.952   254.7  33640.6    464.0       0.0      0.0     464.0      0.0     4.    0.     0.
 Grang    0.000 2774.775   662.6  15506.2   1844.8       0.0    812.1    1493.0   47635.7    35.  727. 47636.
 Camer    0.000 9258.413     0.0      0.0   7121.5       0.0   4628.5    5258.0   45117.3   373. 1808. 44784.
 Bryan    0.000 5692.078     0.0      0.0   5692.1       0.0   2910.0   18746.0   70862.4   567. 1870. 43172.
```

SIM YRO File

Yield Versus Reliability Table for the Following Water Right(s):

One right (100%): WR-24 Hemp

If more than one right, the target amount is distributed using the percentages shown above. The total number of periods is 696. The period reliability is the percentage of the periods for which at least 100.0 percent (FY record field 2; default=100%) of the target is supplied. The table below ends with the maximum target that results in a mean annual shortage of less than 0.05 units.

Iteration	Level	Annual Target	Mean Shortage	Mean Actual	Volume Reliability (%)	Periods Without Shortage	Period Reliability (%)
1	0	1200000.0	89190.1	1110809.9	92.57	621	89.22
2	1	1100000.0	63632.8	1036367.2	94.22	635	91.24
3	1	1000000.0	47099.2	952900.8	95.29	652	93.68
4	1	900000.0	33245.1	866754.9	96.31	659	94.68
5	1	800000.0	23458.7	776541.3	97.07	667	95.83
6	1	700000.0	16235.5	683764.4	97.68	674	96.84
7	1	600000.0	9186.1	590813.9	98.47	678	97.41
8	1	500000.0	3887.0	496113.0	99.22	682	97.99
9	1	400000.0	612.0	399388.0	99.85	688	98.85
10	1	300000.0	0.00	300000.0	100.00	692	99.43

11	2	390000.0	543.5	389456.5	99.86	689	98.99
12	2	380000.0	661.5	379338.5	99.83	693	99.57
13	2	370000.0	615.9	369384.1	99.83	689	98.99
14	2	360000.0	592.5	359407.5	99.84	689	98.99
15	2	350000.0	512.0	349488.0	99.85	692	99.43
16	2	340000.0	642.8	339357.2	99.81	691	99.28
17	2	330000.0	355.3	329644.7	99.89	690	99.14
18	2	320000.0	291.2	319708.8	99.91	695	99.86
19	2	310000.0	151.3	309848.7	99.95	689	98.99
20	2	300000.0	0.00	300000.0	100.00	692	99.43

21	3	309000.0	126.2	308873.8	99.96	690	99.14
22	3	308000.0	100.9	307899.1	99.97	695	99.86
23	3	307000.0	75.9	306924.1	99.98	693	99.57
24	3	306000.0	50.8	305949.2	99.98	690	99.14
25	3	305000.0	25.8	304974.2	99.99	691	99.28
26	3	304000.0	0.16	303999.8	100.00	695	99.86
27	3	303000.0	0.00	303000.0	100.00	691	99.28

28	4	303900.0	0.00	303900.0	100.00	693	99.57

Appendix B – TABLES Files for the Example

TABLES TIN File

```
**   File Example.TIN - TABLES Input File for the Example Dataset
**
PAGE
****---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!
**    Tables of monthly and annual flows at outlet
2NAT   1   2   1   0   1    Hemp
2REG   1   2   1   0   1    Hemp
2UNA   1   2   1   0   1    Hemp
2IFS   1   2   0   1   1            IF-2
****---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!
**    Frequency tables
2FRE   1
2FRE   2
2FRE   3
2FRE   4
2FRE  -4
2FRE   4   8
2FRQ   6   0   7            IF-2      1.   2000.   4000.   6000.   8000.  10000.  12000.
****---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!
**    Reliability tables
2REL
2REL   0   0   1
2REL   0   0   1   8
2REL   0   0   2   0   1    Whit
2REL   0   0   3   0  11      PK WhitneyWacoLake  Belton  George Granger CameronWacoGage
2REL                    Highbank   Bryan    Hemp
****---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!
**    Reservoir storage tables
2RES   0   0   6      PK    Whit   WacoL  Belton  George   Grang
2RES             570240. 627100. 192100. 457600.  37100.  65500.
2RES                  0. 379000.    580.      0.    240.    220.
****---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!
**    Summary water budget tables
2SCP   0   1  Belton
2SBA
****---!---!---!---!---!---!---!---!---!---!---!---!---!---!---!
ENDF
```

TABLES TMS File

```
  TABLES MESSAGE FILE

*** File was opened: Example.TIN
*** File was opened: Example.TAB
*** Identifiers for the 37 records in the TIN file were checked.
*** File was opened: Example.OUT
*** Tables are being developed as specified by a PAGE record.
*** Tables are being developed as specified by a 2NAT record.
*** Tables are being developed as specified by a 2REG record.
*** Tables are being developed as specified by a 2UNA record.
*** Tables are being developed as specified by a 2IFS record.
*** Tables are being developed as specified by a 2FRE record.
*** Tables are being developed as specified by a 2FRE record.
*** Tables are being developed as specified by a 2FRE record.
*** Tables are being developed as specified by a 2FRE record.
*** Tables are being developed as specified by a 2FRE record.
*** Tables are being developed as specified by a 2FRE record.
*** Tables are being developed as specified by a 2FRQ record.
*** Tables are being developed as specified by a 2REL record.
*** Tables are being developed as specified by a 2REL record.
*** Tables are being developed as specified by a 2REL record.
*** Tables are being developed as specified by a 2REL record.
*** Tables are being developed as specified by a 2REL record.
*** Tables are being developed as specified by a 2RES record.
*** Tables are being developed as specified by a 2SCP record.
*** Tables are being developed as specified by a 2SBA record.

    Program TABLES output is in file Example.TAB

  ***** Normal Completion of Program TABLES *****
```

TABLES TAB File

```
 ************************************************
 **                                            **
 **      Water Rights Analysis Package (WRAP)  **
 **                                            **
 **     Program WRAP-SIM (April 2005 Version)  **
 **     Program TABLES   (April 2005 Version)  **
 **                                            **
 ************************************************



 Title records from WRAP-SIM output file:

File Example.DAT - WRAP-SIM Input Data File for the Example Dataset
WRAP Fundamentals Manual
April 2005


 The program WRAP-SIM output file contains simulation results for:
      29 water rights
      11 control points
       6 reservoirs
 for a period-of-analysis of 58 years beginning in 1940.


 Program TABLES input file name:  Example.TIN
 Program TABLES output file name: Example.TAB

 Root of SIM input and output file names:  Example
```

NATURALIZED STREAMFLOWS (AC-FT) AT CONTROL POINT Hemp

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1940	31649.	149252.	27695.	196282.	365200.	666231.	1169486.	270115.	104997.	50295.	1583495.	2555544.	7170241.
1941	979247.	1259427.	1410847.	975472.	2546961.	1875876.	1090395.	388553.	218960.	696833.	480542.	141057.	12064170.
1942	121393.	91784.	81192.	2179374.	1850681.	1212632.	208758.	113332.	854651.	724460.	391231.	254386.	8083874.
1943	279554.	113167.	206331.	295216.	245966.	237667.	79149.	49937.	69436.	82924.	34605.	57693.	1751645.
1944	603980.	918535.	1001117.	285474.	2873796.	1001503.	164640.	69063.	271160.	102043.	365181.	719386.	8375878.
1945	1276691.	864126.	1398517.	2609295.	749772.	602670.	528789.	235452.	293930.	544515.	120165.	413931.	9637853.
1946	653823.	838507.	1171932.	460555.	1593600.	791868.	143680.	90003.	288793.	258803.	943606.	581968.	7817138.
1947	967054.	277792.	799364.	432632.	1000379.	330429.	89100.	294904.	86481.	56047.	68393.	167787.	4570362.
1948	90928.	228449.	251691.	151640.	313736.	230559.	258435.	10553.	56224.	33495.	21402.	20067.	1667179.
1949	78887.	260971.	476037.	786002.	992587.	531892.	172161.	30154.	123287.	310064.	165044.	214944.	4142030.
1950	219525.	778977.	131749.	541312.	521446.	523812.	263841.	216518.	313186.	108914.	26230.	17031.	3662541.
1951	15207.	44126.	55950.	51715.	186879.	373289.	31797.	35161.	74310.	18355.	17456.	23650.	927895.
1952	14584.	38133.	66313.	320690.	447995.	177531.	43692.	11655.	32385.	9679.	82696.	213925.	1459278.
1953	262336.	122828.	264576.	128562.	1734824.	85533.	289579.	111503.	81150.	482958.	155645.	510893.	4230387.
1954	96914.	38213.	23136.	135825.	543755.	137147.	29520.	44145.	12564.	36126.	68415.	14727.	1180487.
1955	23870.	229331.	71597.	323650.	569680.	391928.	115768.	78914.	218878.	623460.	43803.	21439.	2712318.
1956	30701.	102189.	37891.	47356.	433953.	44879.	1634.	16265.	12692.	24875.	57094.	87294.	896823.
1957	4983.	240691.	167160.	2568254.	5723482.	1563516.	412593.	118375.	75236.	1571016.	902606.	393684.	13741596.
1958	428237.	917721.	681009.	474546.	1586400.	258628.	381415.	79575.	316633.	149950.	84251.	72065.	5430430.
1959	54251.	267828.	65307.	705377.	426648.	471757.	282043.	124281.	55047.	1749067.	375414.	622517.	5199537.
1960	991606.	610913.	330551.	235048.	362811.	294999.	348187.	82951.	25567.	606895.	831489.	1458011.	6179028.
1961	2107646.	1757544.	657025.	245138.	167692.	960668.	825945.	172881.	612471.	296901.	268215.	346054.	8418180.
1962	198952.	157195.	111584.	125411.	155133.	523480.	283469.	156251.	582922.	241867.	152608.	317691.	3006563.
1963	112459.	220827.	72293.	285620.	200972.	228453.	63967.	13864.	17487.	44083.	96132.	45407.	1401564.
1964	55018.	140692.	214184.	161320.	135623.	206353.	37633.	51320.	320412.	114096.	366471.	111815.	1914937.
1965	512579.	1141899.	325572.	481283.	3317693.	756080.	149761.	113575.	123720.	156596.	336741.	437181.	7852680.
1966	186492.	395632.	341482.	1239757.	1753597.	271615.	81829.	272223.	761202.	237372.	61597.	46787.	5649585.
1967	54785.	39489.	49525.	172063.	214084.	265024.	178062.	46137.	115587.	50466.	255044.	157995.	1598261.
1968	1577285.	591053.	1152758.	1033428.	2133373.	1501392.	959391.	136448.	221552.	91552.	187534.	441812.	10027578.
1969	121791.	484390.	881621.	1373049.	1479366.	268529.	95023.	97285.	181225.	131155.	166803.	376160.	5656397.
1970	309248.	412725.	1513766.	656693.	680633.	288744.	72671.	52029.	192553.	247942.	76152.	44224.	4547380.
1971	46217.	48046.	53264.	80858.	167206.	111206.	234632.	388117.	165204.	447274.	248305.	799363.	2789692.
1972	367814.	185870.	90362.	87469.	356637.	132853.	64217.	156411.	146325.	156556.	333173.	159534.	2237221.
1973	553526.	499478.	917929.	1141903.	765278.	1285441.	296829.	116055.	115399.	1388675.	396771.	311506.	7788790.
1974	618261.	300706.	157541.	145702.	277366.	99666.	43784.	202878.	1455959.	745384.	1756798.	635887.	6439932.
1975	468052.	1272532.	397376.	572971.	1641343.	997355.	406470.	203682.	120802.	78261.	70798.	51284.	6280926.
1976	59720.	82315.	124738.	831033.	1179574.	580397.	722520.	127073.	170039.	423639.	320119.	1014481.	5635648.
1977	290921.	1068526.	694134.	2203544.	932250.	306451.	83924.	38212.	55110.	32332.	40988.	51699.	5798091.
1978	106453.	175122.	183700.	112048.	70443.	109154.	24848.	582065.	107065.	36859.	115811.	57279.	1680847.
1979	528610.	502161.	1069097.	1033116.	1708268.	1723060.	513684.	298262.	115345.	80444.	56065.	135154.	7763266.
1980	323916.	315431.	222570.	291071.	1152382.	165196.	54795.	27014.	141877.	267028.	45408.	81313.	3088001.
1981	53621.	77358.	206760.	178571.	250892.	2121400.	325283.	69527.	171955.	1329981.	588323.	110133.	5483804.
1982	81239.	97408.	181883.	307057.	1392499.	977158.	517124.	80016.	33258.	33797.	48844.	167437.	3917720.
1983	172083.	601953.	629652.	195351.	918028.	305570.	70473.	166073.	93960.	121396.	54372.	68762.	3397673.
1984	78121.	62984.	213275.	46299.	55113.	82913.	36647.	22127.	29996.	987290.	452171.	721804.	2788740.
1985	620687.	572057.	816897.	376784.	412320.	282655.	97308.	22543.	36880.	411944.	576601.	899723.	5126399.
1986	123290.	833625.	162462.	116209.	695990.	1417331.	191026.	98688.	411128.	618635.	499226.	1305623.	6473233.
1987	577625.	629530.	993087.	302711.	554962.	2540490.	425944.	111835.	98232.	45889.	101558.	248305.	6630168.
1988	144969.	115134.	204845.	95933.	69793.	265448.	84472.	40232.	81178.	28898.	16980.	38256.	1186138.
1989	143791.	255549.	348272.	264405.	1488755.	1276206.	232013.	225749.	141786.	46324.	36463.	25994.	4485307.
1990	100485.	182484.	742057.	1621648.	2270261.	773373.	149586.	124610.	155366.	84240.	136672.	61999.	6402781.
1991	1484722.	576109.	243366.	740937.	805597.	740061.	152030.	244969.	236119.	456988.	455183.	4207432.	10343513.
1992	2451762.	4311366.	2412275.	810612.	1442859.	1798214.	451334.	246073.	171630.	89174.	153176.	489895.	14828370.
1993	593590.	727150.	1236710.	789956.	1058495.	949474.	256004.	80824.	65237.	292942.	100426.	89698.	6240506.
1994	112549.	311766.	300244.	120805.	1003331.	353978.	102010.	66999.	81264.	1361316.	291312.	939402.	5044976.
1995	755368.	215509.	767654.	853542.	977541.	744128.	184029.	768878.	196337.	110463.	55849.	136473.	5765771.
1996	44289.	56533.	41905.	88978.	46110.	77653.	38466.	211058.	679088.	173684.	220595.	492921.	2171280.
1997	416542.	2072283.	1962688.	1703986.	1171238.	1154625.	432531.	155466.	66324.	103043.	111824.	705526.	10056076.
MEAN	409998.	515231.	507147.	599854.	1002987.	662864.	259386.	145842.	207889.	341470.	277067.	429207.	5358943.

REGULATED STREAMFLOWS (AC-FT) AT CONTROL POINT Hemp

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1940	9993.	66434.	11104.	38281.	133715.	298598.	853112.	102698.	10746.	11104.	1251530.	2426355.	5213671.
1941	883399.	1159732.	1298274.	854724.	2388782.	1646043.	768406.	129443.	69166.	600099.	339594.	35091.	10172755.
1942	9393.	9338.	11104.	1980818.	1688475.	967666.	8592.	11104.	462860.	571499.	269302.	151881.	6142032.
1943	193879.	22998.	70981.	126834.	92890.	16003.	11104.	11104.	10746.	11104.	11104.	0.	578751.
1944	477861.	643784.	712231.	155447.	2574787.	742989.	11104.	11104.	136351.	11104.	277591.	572767.	6327120.
1945	992903.	564468.	1184506.	2423762.	574020.	352422.	142774.	77979.	210878.	271127.	25089.	326489.	7146418.
1946	536324.	695788.	1066625.	342551.	1438948.	529839.	11104.	11104.	10746.	16144.	786653.	424536.	5870364.
1947	806619.	169108.	692086.	318786.	805735.	85301.	11104.	121846.	10945.	11104.	11104.	10342.	3054082.
1948	12388.	66369.	110530.	47407.	67526.	10746.	11104.	11104.	10746.	11104.	11104.	0.	370130.
1949	21090.	150872.	272615.	536764.	468581.	133569.	2488.	11104.	10746.	126342.	85016.	156325.	1975512.
1950	150292.	616153.	55232.	355851.	174066.	280026.	11104.	11104.	10746.	11104.	11104.	0.	1686783.
1951	11104.	10030.	11104.	10746.	11104.	16243.	9381.	8039.	10746.	11104.	11104.	0.	120708.
1952	11104.	10030.	11420.	132983.	137730.	10746.	11104.	4597.	7505.	11068.	11104.	74917.	434310.
1953	190027.	47305.	123852.	10746.	1321905.	10746.	11104.	7233.	10746.	94981.	69714.	431619.	2329978.
1954	22518.	10030.	7364.	6884.	30497.	10746.	10588.	1364.	7843.	9278.	11104.	0.	128216.
1955	11104.	132437.	11104.	191971.	11104.	10746.	11104.	8175.	0.	164577.	11104.	0.	563428.
1956	11104.	13522.	11104.	10525.	45650.	3538.	4535.	3541.	10746.	11104.	11104.	0.	136476.
1957	11104.	10030.	25516.	1465209.	5456696.	1318310.	93844.	11104.	10746.	1219057.	799296.	287864.	10708777.
1958	335449.	834262.	553780.	354737.	1428739.	21054.	97564.	11104.	112957.	76096.	20694.	11290.	3857728.
1959	11104.	190966.	11104.	605321.	262053.	73648.	11104.	11104.	10746.	1056290.	278296.	522826.	3044564.
1960	888784.	510102.	222004.	101341.	211345.	118407.	19290.	11104.	10746.	199383.	692148.	1290386.	4275040.
1961	2032082.	1666042.	536317.	124812.	12417.	705436.	517393.	723.	447585.	108014.	156988.	249752.	6557560.
1962	120980.	82886.	27570.	16449.	38475.	141194.	64673.	11104.	313421.	83749.	48252.	219321.	1168076.
1963	45185.	155910.	11104.	67378.	48164.	15364.	7135.	10606.	10746.	11104.	11104.	0.	393802.
1964	11104.	16422.	83259.	10746.	11104.	10746.	11104.	6825.	47054.	11104.	88961.	28790.	337222.
1965	390057.	828855.	164580.	314064.	2664579.	515750.	11104.	11104.	10746.	11104.	152525.	323863.	5398332.
1966	105713.	289958.	229205.	809798.	1455161.	28428.	11104.	22394.	449026.	112909.	11104.	0.	3524800.
1967	11104.	10030.	11104.	10746.	33035.	10746.	553.	0.	10746.	11104.	171557.	69203.	349930.
1968	977552.	395961.	922586.	908113.	1994221.	1265636.	645446.	574.	139908.	17278.	115589.	362943.	7745806.
1969	56475.	402979.	644677.	1025092.	1304223.	18044.	11104.	0.	10746.	11104.	20678.	190703.	3695825.
1970	161412.	238955.	1295176.	524145.	518377.	63248.	11104.	11104.	10746.	153419.	14550.	0.	3002237.
1971	11104.	10030.	11104.	10746.	11104.	10746.	11104.	11104.	10746.	11104.	76139.	618230.	803264.
1972	249771.	73522.	4771.	10746.	126323.	10746.	11104.	11104.	1099.	11104.	102218.	65055.	677565.
1973	388477.	326950.	704108.	925535.	569819.	1006044.	9436.	2417.	0.	1153807.	299339.	236095.	5622027.
1974	533284.	218381.	66333.	26286.	148432.	10746.	389.	11104.	920538.	299466.	1524812.	498038.	4257810.
1975	346298.	1177700.	277553.	446252.	1506846.	749670.	136942.	11104.	22405.	12215.	11104.	0.	4698090.
1976	11104.	10030.	52121.	618992.	884564.	350956.	368241.	11104.	25047.	214570.	167515.	875180.	3589424.
1977	185965.	924031.	500073.	2070785.	770986.	61051.	11104.	11104.	10746.	11104.	11104.	0.	4568055.
1978	56003.	107857.	103056.	10746.	11104.	10746.	9818.	0.	10746.	0.	11877.	0.	331956.
1979	413652.	365210.	679696.	760925.	1361457.	1334979.	260192.	121976.	45686.	11104.	11104.	58769.	5424752.
1980	252125.	222237.	142839.	180863.	717421.	10746.	11104.	11104.	10746.	11104.	11104.	0.	1581395.
1981	11104.	10030.	17240.	10746.	88179.	1439613.	99020.	11104.	27129.	798879.	482917.	30763.	3026725.
1982	11104.	0.	42561.	177048.	1161465.	743717.	199244.	11104.	10746.	11104.	11104.	104196.	2483395.
1983	109092.	494414.	482539.	90818.	622537.	94681.	11104.	28424.	40786.	11104.	11104.	0.	1996605.
1984	11104.	10030.	81098.	10746.	11104.	10746.	11104.	11104.	7338.	648641.	305125.	493173.	1611314.
1985	388089.	417428.	541034.	106165.	115239.	10746.	11104.	7506.	10746.	90365.	474784.	752720.	2925927.
1986	44319.	665437.	69688.	19376.	459633.	813970.	11104.	11104.	14454.	408211.	354334.	1199880.	4071513.
1987	470971.	536309.	874444.	156844.	406415.	2326762.	133865.	11104.	11915.	11104.	11104.	129347.	5080187.
1988	53799.	31282.	122788.	14321.	11104.	10746.	11104.	11104.	10746.	11104.	11104.	0.	299205.
1989	47850.	76604.	154224.	119026.	930353.	790511.	11900.	55499.	10746.	11104.	11104.	0.	2218921.
1990	11104.	66402.	399560.	1019053.	2029157.	514669.	11104.	11104.	10746.	11104.	31910.	2865.	4118780.
1991	1321428.	450977.	144830.	570475.	498022.	415200.	11104.	11104.	10746.	257343.	279032.	4085275.	8055538.
1992	2368490.	4228113.	2299175.	672410.	1298280.	1561612.	137918.	49667.	55696.	11548.	56721.	344753.	13084383.
1993	495900.	519595.	1122174.	660360.	894520.	707701.	42527.	11104.	10746.	22029.	20587.	9477.	4516720.
1994	30728.	183589.	185500.	27400.	571370.	115823.	4475.	11104.	10746.	1107842.	137651.	800963.	3187192.
1995	629025.	114820.	611017.	713988.	818687.	450442.	0.	332236.	43911.	11104.	11104.	70937.	3807274.
1996	11104.	10030.	11104.	10746.	11104.	0.	6394.	11104.	140824.	12895.	53733.	294708.	573748.
1997	276482.	1640352.	1841446.	1591873.	1011367.	923782.	106202.	9861.	10746.	26975.	43260.	488429.	7970777.
MEAN	314633.	395054.	378298.	429591.	766391.	412399.	87260.	25327.	70599.	176443.	177917.	333209.	3567120.

UNAPPROPRIATED FLOWS (AC-FT) AT CONTROL POINT Hemp

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1940	0.	56404.	0.	27534.	122610.	287852.	842008.	91593.	0.	0.	1240425.	2426355.	5094782.
1941	872295.	1149702.	1287170.	843978.	2377678.	1635297.	757302.	118339.	58420.	588995.	328489.	35091.	10052755.
1942	0.	0.	0.	1970072.	1677371.	956919.	0.	0.	452113.	560395.	258198.	151881.	6026948.
1943	182775.	12969.	59877.	116088.	81785.	5257.	0.	0.	0.	0.	0.	0.	458751.
1944	466756.	633754.	701126.	144700.	2563682.	732242.	0.	0.	125605.	0.	266486.	572767.	6207120.
1945	981799.	554438.	1173401.	2413016.	562916.	341676.	131670.	66874.	200132.	260023.	13985.	326489.	7026418.
1946	525220.	685758.	1055520.	331804.	1427844.	519092.	0.	0.	0.	5040.	775549.	424536.	5750363.
1947	795515.	159078.	680982.	308040.	794630.	74554.	0.	110741.	199.	0.	0.	10342.	2934082.
1948	1283.	56339.	99426.	36661.	56421.	0.	0.	0.	0.	0.	0.	0.	250130.
1949	9986.	140842.	261511.	526018.	457476.	122823.	0.	0.	0.	115237.	73911.	156325.	1864129.
1950	139187.	606123.	44128.	345104.	162961.	269280.	0.	0.	0.	0.	0.	0.	1566783.
1951	0.	0.	0.	0.	0.	5497.	0.	0.	0.	0.	0.	0.	5497.
1952	0.	0.	316.	122237.	126625.	0.	0.	0.	0.	0.	0.	74917.	324095.
1953	178923.	37275.	112748.	0.	1310800.	0.	0.	0.	0.	83876.	58609.	431619.	2213850.
1954	11413.	0.	0.	0.	19392.	0.	0.	0.	0.	0.	0.	0.	30806.
1955	0.	122408.	0.	181224.	0.	0.	0.	0.	0.	153472.	0.	0.	457104.
1956	0.	3492.	0.	0.	34546.	0.	0.	0.	0.	0.	0.	0.	38039.
1957	0.	0.	14411.	1454463.	5445592.	1307564.	82739.	0.	0.	1207952.	788192.	287864.	10588778.
1958	324344.	824232.	542675.	343991.	1417635.	10308.	86460.	0.	102211.	64992.	9590.	11290.	3737728.
1959	0.	180937.	0.	594574.	250949.	62902.	0.	0.	0.	1045185.	267192.	522826.	2924564.
1960	877680.	500072.	210899.	90595.	200240.	107661.	8186.	0.	0.	188279.	681044.	1290386.	4155040.
1961	2020977.	1656012.	525213.	114066.	1312.	694689.	506288.	0.	436839.	96909.	145884.	249752.	6447942.
1962	109876.	72856.	16466.	5703.	27371.	130448.	53568.	0.	302674.	72645.	37148.	219321.	1048075.
1963	34080.	145880.	0.	56632.	37060.	4617.	0.	0.	0.	0.	0.	0.	278270.
1964	0.	6392.	72155.	0.	0.	0.	0.	0.	36308.	0.	77856.	28790.	221501.
1965	378953.	818825.	153475.	303317.	2653474.	505003.	0.	0.	0.	0.	141420.	323863.	5278332.
1966	94608.	279928.	218100.	799052.	1444056.	17682.	0.	11290.	438280.	101805.	0.	0.	3404800.
1967	0.	0.	0.	0.	21931.	0.	0.	0.	0.	0.	160452.	69203.	251586.
1968	966448.	385931.	911482.	897367.	1983117.	1254889.	634342.	0.	129162.	6173.	104484.	362943.	7636336.
1969	45370.	392949.	633572.	1014346.	1293119.	7297.	0.	0.	0.	0.	9574.	190703.	3586930.
1970	150308.	228925.	1284071.	513398.	507273.	52502.	0.	0.	0.	142314.	3445.	0.	2882236.
1971	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	65034.	618230.	683264.
1972	238666.	63492.	0.	0.	115218.	0.	0.	0.	0.	0.	91114.	65055.	573546.
1973	377373.	316920.	693003.	914789.	558715.	995298.	0.	0.	0.	1142703.	288234.	236095.	5523130.
1974	522180.	208351.	55228.	15540.	137327.	0.	0.	0.	909792.	288362.	1513708.	498038.	4148526.
1975	335194.	1167670.	266448.	435506.	1495741.	738923.	125838.	0.	11659.	1111.	0.	0.	4578090.
1976	0.	0.	41016.	608246.	873459.	340209.	357136.	0.	14300.	203466.	156411.	875180.	3469424.
1977	174860.	914001.	488968.	2060039.	759882.	50304.	0.	0.	0.	0.	0.	0.	4448054.
1978	44899.	97828.	91952.	0.	0.	0.	0.	0.	0.	0.	772.	0.	235451.
1979	402547.	355180.	668592.	750179.	1350353.	1324233.	249088.	110872.	34940.	0.	0.	58769.	5304752.
1980	241020.	212207.	131735.	170117.	706316.	0.	0.	0.	0.	0.	0.	0.	1461395.
1981	0.	0.	6135.	0.	77074.	1428866.	87915.	0.	16383.	787775.	471812.	30763.	2906725.
1982	0.	0.	31457.	166302.	1150360.	732970.	188140.	0.	0.	0.	0.	104196.	2373425.
1983	97988.	484384.	471434.	80072.	611432.	83935.	0.	17320.	30040.	0.	0.	0.	1876604.
1984	0.	0.	69994.	0.	0.	0.	0.	0.	0.	637536.	294020.	493173.	1494723.
1985	376984.	407399.	529930.	95418.	104134.	0.	0.	0.	0.	79260.	463680.	752720.	2809525.
1986	33214.	655407.	58583.	8630.	448529.	803223.	0.	0.	3708.	397107.	343230.	1199880.	3951512.
1987	459867.	526279.	863339.	146098.	395310.	2316016.	122760.	0.	1169.	0.	0.	129347.	4960186.
1988	42695.	21252.	111683.	3575.	0.	0.	0.	0.	0.	0.	0.	0.	179204.
1989	36745.	66574.	143120.	108279.	919249.	779764.	796.	44394.	0.	0.	0.	0.	2098921.
1990	0.	56373.	388456.	1008306.	2018052.	503923.	0.	0.	0.	0.	20806.	2865.	3998780.
1991	1310324.	440947.	133726.	559729.	486918.	404454.	0.	0.	0.	246238.	267927.	4085275.	7935538.
1992	2357386.	4218083.	2288070.	661664.	1287175.	1550866.	126814.	38563.	44949.	444.	45617.	344753.	12964384.
1993	484796.	509565.	1111069.	649614.	883416.	696955.	31423.	0.	0.	10924.	9482.	9477.	4396721.
1994	19624.	173559.	174395.	16654.	560266.	105076.	0.	0.	0.	1096738.	126546.	800963.	3073822.
1995	617920.	104790.	599913.	703242.	807583.	439696.	0.	321132.	33165.	0.	0.	70937.	3698378.
1996	0.	0.	0.	0.	0.	0.	0.	0.	130078.	1791.	42629.	294708.	469205.
1997	265378.	1630322.	1830342.	1581127.	1000262.	913036.	95098.	0.	0.	15870.	32155.	488429.	7852019.
MEAN	303577.	385209.	367367.	418916.	755287.	401962.	77372.	16054.	60554.	165562.	166812.	333209.	3451881.

INSTREAM FLOW SHORTAGES (AC-FT) FOR WATER RIGHT IF-2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1940	1111.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1111.50
1941	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1942	1711.70	692.00	0.00	0.00	0.00	0.00	2512.20	0.00	0.00	0.00	0.00	0.00	4915.90
1943	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1944	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1945	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1946	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1947	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1948	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1949	0.00	0.00	0.00	0.00	0.00	0.00	8616.60	0.00	0.00	0.00	0.00	0.00	8616.60
1950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1951	0.00	0.00	0.00	0.00	0.00	0.00	1723.10	3065.60	0.00	0.00	0.00	0.00	4788.70
1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6507.30	3241.00	36.00	0.00	0.00	9784.30
1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3871.60	0.00	0.00	0.00	0.00	3871.60
1954	0.00	0.00	3741.00	3861.90	0.00	0.00	516.30	9740.40	2903.10	1826.50	0.00	0.00	22589.20
1955	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2929.90	10746.30	0.00	0.00	0.00	13676.20
1956	0.00	0.00	0.00	221.60	0.00	7208.70	6569.20	7563.00	0.00	0.00	0.00	0.00	21562.50
1957	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1958	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1959	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1960	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1961	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10381.70	0.00	0.00	0.00	0.00	10381.70
1962	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1963	0.00	0.00	0.00	0.00	0.00	0.00	3969.50	498.30	0.00	0.00	0.00	0.00	4467.80
1964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4279.30	0.00	0.00	0.00	0.00	4279.30
1965	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1966	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1967	0.00	0.00	0.00	0.00	0.00	0.00	10551.80	11104.50	0.00	0.00	0.00	0.00	21656.30
1968	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10530.70	0.00	0.00	0.00	0.00	10530.70
1969	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11104.50	0.00	0.00	0.00	0.00	11104.50
1970	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1971	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1972	0.00	0.00	6333.70	0.00	0.00	0.00	0.00	0.00	9647.00	0.00	0.00	0.00	15980.70
1973	0.00	0.00	0.00	0.00	0.00	0.00	1668.70	8687.30	10746.30	0.00	0.00	0.00	21102.30
1974	0.00	0.00	0.00	0.00	0.00	0.00	10715.60	0.00	0.00	0.00	0.00	0.00	10715.60
1975	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1978	0.00	0.00	0.00	0.00	0.00	0.00	1286.50	11104.50	0.00	11104.50	0.00	0.00	23495.50
1979	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1981	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1982	0.00	10029.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10029.90
1983	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1984	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3408.60	0.00	0.00	0.00	3408.60
1985	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3598.10	0.00	0.00	0.00	0.00	3598.10
1986	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	6629.10	0.00	0.00	0.00	0.00	0.00	6629.10
1995	0.00	0.00	0.00	0.00	0.00	0.00	11104.50	0.00	0.00	0.00	0.00	0.00	11104.50
1996	0.00	0.00	0.00	0.00	0.00	10746.30	4710.80	0.00	0.00	0.00	0.00	0.00	15457.10
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1243.10	0.00	0.00	0.00	0.00	1243.10
MEAN	48.68	184.86	173.70	70.41	0.00	309.57	1216.79	1831.20	701.59	223.57	0.00	0.00	4760.37

	NAT Hemp	REG Hemp	UNA Hemp	IFS IF-2
1940	7170241.	5213671.	5094782.	1112.
1941	12064170.	10172755.	10052755.	0.
1942	8083874.	6142032.	6026948.	4916.
1943	1751645.	578751.	458751.	0.
1944	8375878.	6327120.	6207120.	0.
1945	9637853.	7146418.	7026418.	0.
1946	7817138.	5870364.	5750363.	0.
1947	4570362.	3054082.	2934082.	0.
1948	1667179.	370130.	250130.	0.
1949	4142030.	1975512.	1864129.	8617.
1950	3662541.	1686783.	1566783.	0.
1951	927895.	120708.	5497.	4789.
1952	1459278.	434310.	324095.	9784.
1953	4230387.	2329978.	2213850.	3872.
1954	1180487.	128216.	30806.	22589.
1955	2712318.	563428.	457104.	13676.
1956	896823.	136476.	38039.	21562.
1957	13741596.	10708777.	10588778.	0.
1958	5430430.	3857728.	3737728.	0.
1959	5199537.	3044564.	2924564.	0.
1960	6179028.	4275040.	4155040.	0.
1961	8418180.	6557560.	6447942.	10382.
1962	3006563.	1168076.	1048075.	0.
1963	1401564.	393802.	278270.	4468.
1964	1914937.	337222.	221501.	4279.
1965	7852680.	5398332.	5278332.	0.
1966	5649585.	3524800.	3404800.	0.
1967	1598261.	349930.	251586.	21656.
1968	10027578.	7745806.	7636336.	10531.
1969	5656397.	3695825.	3586930.	11104.
1970	4547380.	3002237.	2882236.	0.
1971	2789692.	803264.	683264.	0.
1972	2237221.	677565.	573546.	15981.
1973	7788790.	5622027.	5523130.	21102.
1974	6439932.	4257810.	4148526.	10716.
1975	6280926.	4698090.	4578090.	0.
1976	5635648.	3589424.	3469424.	0.
1977	5798091.	4568055.	4448054.	0.
1978	1680847.	331956.	235451.	23496.
1979	7763266.	5424752.	5304752.	0.
1980	3088001.	1581395.	1461395.	0.
1981	5483804.	3026725.	2906725.	0.
1982	3917720.	2483395.	2373425.	10030.
1983	3397673.	1996605.	1876604.	0.
1984	2788740.	1611314.	1494723.	3409.
1985	5126399.	2925927.	2809525.	3598.
1986	6473233.	4071513.	3951512.	0.
1987	6630168.	5080187.	4960186.	0.
1988	1186138.	299205.	179204.	0.
1989	4485307.	2218921.	2098921.	0.
1990	6402781.	4118780.	3998780.	0.
1991	10343513.	8055538.	7935538.	0.
1992	14828370.	13084383.	12964384.	0.
1993	6240506.	4516720.	4396721.	0.
1994	5044976.	3187192.	3073822.	6629.
1995	5765771.	3807274.	3698378.	11104.
1996	2171280.	573748.	469205.	15457.
1997	10056076.	7970777.	7852019.	1243.

FLOW-FREQUENCY FOR NATURALIZED STREAMFLOWS

CONTROL POINT	MEAN	STANDARD DEVIATION	PERCENTAGE OF MONTHS WITH FLOWS EQUALING OR EXCEEDING VALUES SHOWN IN THE TABLE 100%	99%	98%	95%	90%	75%	60%	50%	40%	25%	10%	MAXIMUM
PK	66123.6	137151.	0.0	0.0	0.0	284.0	2186.8	6883.0	12816.	18404.	30992.	64391.	166331.	1794495.
Whit	114921.1	204744.	0.0	0.0	1717.0	3425.4	6929.0	16626.0	28719.	46163.	65837.	131747.	280970.	2981239.
WacoL	29736.0	53194.	0.0	0.0	0.0	0.0	469.0	2712.0	5984.	9936.	15246.	34506.	80009.	526505.
WacoG	161860.3	266253.	0.0	1576.8	3433.8	6300.4	10363.6	24749.0	45705.	68642.	102411.	183578.	422755.	3376485.
High	194261.6	300104.	1251.0	3561.2	6377.8	8762.8	14725.6	31658.0	60614.	89483.	125100.	232892.	488252.	3599269.
Belton	42104.7	75480.	0.0	0.0	0.0	0.0	478.6	3360.0	7761.	12757.	22410.	47585.	113249.	629618.
George	4826.8	8471.	0.0	0.0	0.0	19.8	85.8	346.0	885.	1425.	2348.	5545.	14575.	75382.
Grang	15772.4	25225.	0.0	0.0	0.0	175.4	481.4	1805.0	3652.	5489.	8552.	19998.	45534.	212283.
Camer	109858.4	170466.	0.0	494.4	1249.0	2706.4	5440.0	15032.0	28988.	44799.	65294.	130473.	290433.	1403136.
Bryan	335663.5	483897.	0.0	6558.6	11161.7	17707.0	28172.8	60717.0	107622.	158629.	232671.	402271.	810073.	4704312.
Hemp	446578.6	588542.	1634.0	13817.1	17422.0	30122.4	44643.0	89698.0	157333.	229331.	306815.	581968.	1153505.	5723482.

FLOW-FREQUENCY FOR REGULATED STREAMFLOWS

CONTROL POINT	MEAN	STANDARD DEVIATION	PERCENTAGE OF MONTHS WITH FLOWS EQUALING OR EXCEEDING VALUES SHOWN IN THE TABLE 100%	99%	98%	95%	90%	75%	60%	50%	40%	25%	10%	MAXIMUM
PK	43325.3	119657.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	4143.	48801.	107827.	1782155.
Whit	68011.0	180138.	0.0	0.0	0.0	0.0	0.0	0.0	0.	1356.	23953.	74587.	170982.	2948706.
WacoL	21636.6	51924.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	17565.	70996.	526119.
WacoG	128680.8	237805.	0.0	3.9	1674.1	4654.7	17245.8	30937.5	44184.	59825.	74682.	116919.	302803.	3362893.
High	157977.4	269613.	0.0	0.0	1118.2	7145.1	22934.6	41110.6	58668.	71222.	95726.	136180.	379279.	3582453.
Belton	26967.9	65183.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	1704.	19741.	92620.	527287.
George	3006.6	7628.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	249.	10841.	65552.
Grang	11352.5	23080.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	1587.	11194.	40700.	200100.
Camer	81866.2	150604.	0.0	187.9	320.7	322.4	333.1	5226.4	13627.	25940.	44874.	91721.	215253.	1392558.
Bryan	270130.6	431027.	0.0	5123.7	15177.2	34252.6	46169.8	68149.6	98013.	114027.	131509.	272898.	672482.	4523193.
Hemp	297260.0	539044.	0.0	0.0	0.0	3402.9	10029.9	11104.5	12399.	56003.	126334.	388477.	886252.	5456696.

FLOW-FREQUENCY FOR UNAPPROPRIATED STREAMFLOWS

CONTROL POINT	MEAN	STANDARD DEVIATION	PERCENTAGE OF MONTHS WITH FLOWS EQUALING OR EXCEEDING VALUES SHOWN IN THE TABLE 100%	99%	98%	95%	90%	75%	60%	50%	40%	25%	10%	MAXIMUM
PK	25932.3	115823.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	0.	43749.	1782155.
Whit	52173.1	180552.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	5900.	155787.	2948706.
WacoL	21332.5	51987.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	15800.	70996.	526119.
WacoG	101729.2	243894.	0.0	0.0	0.0	0.0	0.0	0.0	1361.	24961.	36669.	77109.	300936.	3362893.
High	129700.5	277961.	0.0	0.0	0.0	0.0	0.0	0.0	3221.	32721.	55173.	122426.	372245.	3582453.
Belton	20916.0	64008.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	0.	71050.	527287.
George	2175.7	6521.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	0.	7262.	65552.
Grang	8490.8	21157.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	3816.	30456.	200100.
Camer	72628.2	153001.	0.0	0.0	0.0	0.0	0.0	0.0	0.	8734.	20386.	73039.	213936.	1392258.
Bryan	224397.4	446123.	0.0	0.0	0.0	0.0	0.0	0.0	3553.	40182.	94162.	266756.	644471.	4523193.
Hemp	287656.7	538917.	0.0	0.0	0.0	0.0	0.0	0.0	3464.	44949.	115230.	377373.	876180.	5445592.

STORAGE-FREQUENCY FOR SPECIFIED CONTROL POINTS

CONTROL POINT	MEAN	STANDARD DEVIATION	PERCENTAGE OF MONTHS WITH STORAGE EQUALING OR EXCEEDING VALUES SHOWN IN THE TABLE 100%	99%	98%	95%	90%	75%	60%	50%	40%	25%	10%	MAXIMUM
PK	382645.	181325.	0.	0.	0.	0.	64824.	266965.	375015.	425538.	474602.	553931.	570240.	570240.
Whit	545640.	87163.	342877.	366902.	372144.	379000.	386289.	486597.	539850.	576692.	604246.	627100.	627100.	627100.
WacoL	170129.	28738.	61181.	75904.	84940.	104258.	126952.	158706.	173661.	181575.	190582.	192100.	192100.	192100.
WacoG	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
High	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Belton	273198.	166341.	0.	0.	0.	0.	6076.	120963.	231052.	320687.	374982.	445937.	457600.	457600.
George	18424.	15601.	0.	0.	0.	0.	0.	0.	8370.	20078.	28435.	35305.	37100.	37100.
Grang	37313.	26608.	0.	0.	0.	0.	0.	7755.	28870.	43193.	57030.	65500.	65500.	65500.
Camer	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Bryan	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Hemp	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Total	1427349.	443018.	457611.	481223.	495444.	575132.	721098.	1102227.	1381699.	1519115.	1640756.	1827020.	1948044.	1949640.

STORAGE-FREQUENCY FOR SPECIFIED CONTROL POINTS FOR MONTH 8

CONTROL POINT	MEAN	STANDARD DEVIATION	PERCENTAGE OF MONTHS WITH STORAGE EQUALING OR EXCEEDING VALUES SHOWN IN THE TABLE 100%	99%	98%	95%	90%	75%	60%	50%	40%	25%	10%	MAXIMUM
PK	365423.	48631.	0.	0.	0.	0.	98372.	268279.	388836.	410999.	448796.	495300.	556640.	570240.
Whit	529810.	23897.	346532.	358392.	367540.	373791.	379000.	494120.	530718.	547043.	567773.	593850.	627100.	627100.
WacoL	165361.	6920.	86696.	92292.	99057.	117445.	125895.	161028.	166866.	169240.	174451.	181892.	190946.	192100.
WacoG	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
High	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Belton	257281.	45688.	0.	0.	0.	0.	0.	112249.	225238.	308540.	352257.	405551.	442083.	457600.
George	15125.	4277.	0.	0.	0.	0.	0.	0.	1658.	9570.	22531.	31974.	35169.	37100.
Grang	27607.	7190.	0.	0.	0.	0.	0.	0.	10873.	27326.	42113.	51703.	62467.	65500.
Camer	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Bryan	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Hemp	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Total	1360607.	118710.	467708.	488124.	510869.	600698.	703864.	1046109.	1318255.	1471547.	1545240.	1714280.	1839498.	1945681.

FREQUENCY VERSUS INSTREAM FLOW SHORTAGES FOR WATER RIGHT IF-2

FLOW	FREQ(%)	FLOW	FREQ(%)	FLOW	FREQ(%)	FLOW	FREQ(%)	FLOW	FREQ(%)	FLOW	FREQ(%)	FLOW	FREQ(%)
1.0	6.90	2000.0	5.17	4000.0	3.59	6000.0	3.30	8000.0	2.44	10000.0	1.87	12000.0	0.00

RELIABILITY SUMMARY FOR SELECTED CONTROL POINTS

NAME	TARGET DIVERSION (AC-FT/YR)	MEAN SHORTAGE (AC-FT/YR)	*RELIABILITY* PERIOD (%)	*RELIABILITY* VOLUME (%)	PERCENTAGE OF MONTHS WITH DIVERSIONS EQUALING OR EXCEEDING 100%	95%	90%	75%	50%	25%	>0%	PERCENTAGE OF YEARS PERCENTAGE OF TARGET DIVERSION AMOUNT 100%	98%	95%	90%	75%	50%	>0%
PK	254800.0	10135.51	94.54	96.02	94.5	94.7	94.8	94.8	95.4	96.4	100.0	82.8	82.8	84.5	87.9	94.8	98.3	100.0
Whit	18000.0	958.69	94.68	94.67	94.7	94.7	94.7	94.7	94.8	95.0	100.0	82.8	82.8	82.8	84.5	89.7	94.8	100.0
WacoL	80800.0	0.00	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
WacoG	32300.0	2071.38	95.98	93.59	96.0	96.1	96.3	96.6	96.8	96.8	100.0	69.0	74.1	75.9	84.5	86.2	96.6	100.0
High	44800.0	3629.86	95.83	91.90	95.8	95.8	95.8	96.0	96.6	97.1	100.0	69.0	70.7	72.4	77.6	86.2	93.1	100.0
Belton	180260.0	11917.84	91.67	93.39	91.7	91.8	92.0	92.4	92.5	93.7	100.0	82.8	82.8	86.2	86.2	87.9	93.1	100.0
George	25610.0	4721.70	76.29	81.56	76.3	76.6	77.2	78.4	80.7	83.3	100.0	50.0	53.4	60.3	63.8	70.7	79.3	100.0
Grang	42000.0	4140.04	85.78	90.14	85.8	85.9	86.5	87.4	90.4	92.8	100.0	60.3	62.1	70.7	79.3	86.2	91.4	100.0
Camer	209600.0	34236.55	79.89	83.67	79.9	80.7	81.3	84.5	90.8	96.0	100.0	15.5	17.2	25.9	43.1	79.3	91.4	100.0
Bryan	98900.0	4505.56	91.09	95.44	91.1	91.2	91.5	94.8	98.9	99.3	100.0	56.9	62.1	70.7	77.6	96.6	100.0	100.0
Hemp	1119700.1	57750.37	85.49	94.84	85.5	87.6	89.9	95.0	96.3	97.8	100.0	41.4	60.3	75.9	87.9	91.4	100.0	100.0
Total	2106770.0	134067.50		93.64														

RELIABILITY SUMMARY FOR SELECTED WATER RIGHTS

NAME	TARGET DIVERSION (AC-FT/YR)	MEAN SHORTAGE (AC-FT/YR)	*RELIABILITY* PERIOD (%)	*RELIABILITY* VOLUME (%)	PERCENTAGE OF MONTHS WITH DIVERSIONS EQUALING OR EXCEEDING 100%	95%	90%	75%	50%	25%	>0%	PERCENTAGE OF YEARS PERCENTAGE OF TARGET DIVERSION AMOUNT 100%	98%	95%	90%	75%	50%
WR-5	59100.0	0.00	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
WR-1	9800.0	128.37	98.28	98.69	98.3	98.3	98.4	98.6	98.9	98.9	100.0	87.9	89.7	89.7	93.1	100.0	100.0
WR-2	245000.0	10007.14	94.54	95.92	94.5	94.7	94.8	94.8	95.4	96.3	100.0	82.8	82.8	84.5	87.9	94.8	98.3
WR-14	11300.0	177.48	98.99	98.43	99.0	99.0	99.0	99.0	99.0	99.1	100.0	91.4	91.4	93.1	94.8	98.3	98.3
WR-20	34500.0	366.36	99.14	98.94	99.1	99.1	99.1	99.3	99.4	99.7	100.0	89.7	89.7	91.4	96.6	100.0	100.0
WR-22	49600.0	1427.20	98.13	97.12	98.1	98.1	98.1	98.4	98.7	99.0	100.0	82.8	84.5	89.7	91.4	94.8	100.0
WR-16	32300.0	2071.38	95.98	93.59	96.0	96.1	96.3	96.6	96.8	96.8	100.0	69.0	74.1	75.9	84.5	86.2	96.6
WR-17	44800.0	3629.86	95.83	91.90	95.8	95.8	95.8	96.0	96.6	97.1	100.0	69.0	70.7	72.4	77.6	86.2	93.1
WR-13	18200.0	665.88	96.55	96.34	96.6	96.7	96.7	96.8	97.3	97.4	100.0	79.3	79.3	81.0	82.8	93.1	100.0
WR-19	39000.0	1519.23	96.98	96.10	97.0	97.0	97.0	97.0	97.0	97.3	100.0	75.9	75.9	77.6	82.8	91.4	100.0
WR-21	95600.0	4493.79	95.83	95.30	95.8	95.8	96.0	96.4	96.6	96.7	100.0	69.0	70.7	74.1	77.6	91.4	100.0
WR-8	82760.0	4719.64	92.82	94.30	92.8	92.8	93.4	93.7	94.0	94.5	100.0	82.8	84.5	86.2	86.2	89.7	96.6
WR-9	97500.0	7198.20	91.67	92.62	91.7	91.8	91.8	92.0	92.4	92.4	100.0	82.8	82.8	82.8	86.2	87.9	91.4
WR-10	25610.0	4721.70	76.29	81.56	76.3	76.6	77.2	78.4	80.7	83.3	100.0	50.0	53.4	60.3	63.8	70.7	79.3
WR-11	42000.0	4140.04	85.78	90.14	85.8	85.9	86.5	87.4	90.4	92.8	100.0	60.3	62.1	70.7	79.3	86.2	91.4
WR-6	900.0	0.00	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
WR-3	18000.0	958.69	94.68	94.67	94.7	94.7	94.7	94.7	94.8	95.0	100.0	82.8	82.8	82.8	84.5	89.7	94.8
WR-12	92100.0	28500.47	81.47	69.05	81.5	82.0	82.2	83.3	86.4	91.5	100.0	17.2	19.0	24.1	25.9	44.8	75.9
WR-18	25400.0	2619.98	91.09	89.69	91.1	91.2	91.2	91.4	91.5	91.7	100.0	56.9	58.6	58.6	62.1	81.0	98.3
WR-7	20800.0	0.00	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
WR-15	88000.0	4892.71	93.82	94.44	93.8	93.8	94.1	94.3	94.7	95.1	100.0	84.5	84.5	86.2	87.9	89.7	94.8
WR-23	74500.0	18584.27	87.93	75.05	87.9	87.9	87.9	88.4	88.6	89.9	100.0	43.1	46.6	46.6	53.4	58.6	70.7
WR-24	900000.1	33245.10	95.40	96.31	95.4	95.4	95.4	95.7	96.1	97.7	100.0	84.5	84.5	84.5	87.9	93.1	98.3
WR-4	36000.0	1421.70	94.40	96.05	94.4	94.4	94.5	95.4	96.3	96.7	100.0	79.3	82.8	86.2	86.2	94.8	98.3
WR-25	This water right has zero permitted diversion.																
WR-26	This water right has zero permitted diversion.																
WR-27	This water right has zero permitted diversion.																
WR-28	This water right has zero permitted diversion.																
Total	2142770.0	135489.20		93.68													

RELIABILITY SUMMARY FOR SELECTED WATER RIGHTS FOR MONTH 8

NAME	TARGET DIVERSION (AC-FT/YR)	MEAN SHORTAGE (AC-FT/YR)	*RELIABILITY* PERIOD (%)	*RELIABILITY* VOLUME (%)	PERCENTAGE OF MONTHS WITH DIVERSIONS EQUALING OR EXCEEDING 100%	95%	90%	75%	50%	25%	>0%	PERCENTAGE OF YEARS PERCENTAGE OF TARGET DIVERSION AMOUNT 100%	98%	95%	90%	75%	50%
WR-5	6737.4	0.00	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
WR-1	1117.2	19.26	98.28	98.28	98.3	98.3	98.3	98.3	98.3	98.3	100.0	87.9	89.7	89.7	93.1	100.0	100.0	
WR-2	26022.0	1365.64	93.10	94.75	93.1	93.1	93.1	93.1	94.8	94.8	100.0	82.8	82.8	84.5	87.9	94.8	98.3	
WR-14	2858.9	79.76	96.55	97.21	96.6	96.6	96.6	96.6	96.6	98.3	100.0	91.4	91.4	93.1	94.8	98.3	98.3	
WR-20	8728.5	87.86	96.55	98.99	96.6	96.6	96.6	98.3	100.0	100.0	100.0	89.7	89.7	91.4	96.6	100.0	100.0	
WR-22	12548.8	756.37	89.66	93.97	89.7	89.7	89.7	93.1	94.8	94.8	100.0	82.8	84.5	89.7	91.4	94.8	100.0	
WR-16	8171.9	1182.70	82.76	85.53	82.8	84.5	84.5	84.5	86.2	86.2	100.0	69.0	74.1	75.9	84.5	86.2	96.6	
WR-17	11334.4	2004.52	77.59	82.31	77.6	77.6	77.6	77.6	82.8	87.9	100.0	69.0	70.7	72.4	77.6	86.2	93.1	
WR-13	2256.8	350.19	84.48	84.48	84.5	84.5	84.5	84.5	84.5	84.5	100.0	79.3	79.3	81.0	82.8	93.1	100.0	
WR-19	4836.0	928.85	79.31	80.79	79.3	79.3	79.3	79.3	79.3	82.8	100.0	75.9	75.9	77.6	82.8	91.4	100.0	
WR-21	11854.4	2650.39	74.14	77.64	74.1	74.1	74.1	77.6	77.6	79.3	100.0	69.0	70.7	74.1	77.6	91.4	100.0	
WR-8	9434.6	776.83	91.38	91.77	91.4	91.4	91.4	91.4	91.4	91.4	100.0	82.8	84.5	86.2	86.2	89.7	96.6	
WR-9	10355.7	892.73	91.38	91.38	91.4	91.4	91.4	91.4	91.4	91.4	100.0	82.8	82.8	82.8	86.2	87.9	91.4	
WR-10	2717.4	660.40	72.41	75.70	72.4	72.4	72.4	72.4	74.1	77.6	100.0	50.0	53.4	60.3	63.8	70.7	79.3	
WR-11	4456.5	733.80	77.59	83.53	77.6	77.6	77.6	79.3	84.5	86.2	100.0	60.3	62.1	70.7	79.3	86.2	91.4	
WR-6	211.3	0.00	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
WR-3	2052.0	212.28	89.66	89.66	89.7	89.7	89.7	89.7	89.7	89.7	100.0	82.8	82.8	82.8	84.5	89.7	94.8	
WR-12	23301.3	12212.10	25.86	47.59	25.9	27.6	27.6	32.8	44.8	65.5	100.0	17.2	19.0	24.1	25.9	44.8	75.9	
WR-18	2695.1	916.90	65.52	65.98	65.5	65.5	65.5	65.5	65.5	67.2	100.0	56.9	58.6	58.6	62.1	81.0	98.3	
WR-7	2371.2	0.00	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
WR-15	9337.3	853.62	89.66	90.86	89.7	89.7	89.7	89.7	91.4	91.4	100.0	84.5	84.5	86.2	87.9	89.7	94.8	
WR-23	18848.5	6921.74	62.07	63.28	62.1	62.1	62.1	62.1	62.1	65.5	100.0	43.1	46.6	46.6	53.4	58.6	70.7	
WR-24	95495.5	6921.93	91.38	92.75	91.4	91.4	91.4	93.1	93.1	93.1	100.0	84.5	84.5	84.5	87.9	93.1	98.3	
WR-4	6000.0	270.70	93.10	95.49	93.1	93.1	93.1	94.8	96.6	96.6	100.0	79.3	82.8	86.2	86.2	94.8	98.3	
WR-25	This water right has zero permitted diversion.																	
WR-26	This water right has zero permitted diversion.																	
WR-27	This water right has zero permitted diversion.																	
WR-28	This water right has zero permitted diversion.																	
Total	283742.7	40798.57		85.62														

RELIABILITY SUMMARY FOR SELECTED HYDROELECTRIC POWER PROJECTS

NAME	ENERGY TARGET	MEAN SHORTAGE	*RELIABILITY* PERIOD (%)	*RELIABILITY* AMOUNT (%)	PERCENTAGE OF MONTHS WITH ENERGY GENERATION EQUALING OR EXCEEDING 100%	95%	90%	75%	50%	25%	>0%	PERCENTAGE OF YEARS PERCENTAGE OF TARGET 100%	98%	95%	90%	75%	50%	>0%
Whit	36000.0	1421.70	94.40	96.05	94.4	94.4	94.5	95.4	96.3	96.7	100.0	79.3	82.8	86.2	86.2	94.8	98.3	100.0
Total	36000.0	1421.70		96.05														

RELIABILITY SUMMARY FOR SELECTED WATER RIGHT GROUPS

NAME	TARGET DIVERSION (AC-FT/YR)	MEAN SHORTAGE (AC-FT/YR)	*RELIABILITY* PERIOD (%)	*RELIABILITY* VOLUME (%)	PERCENTAGE OF MONTHS WITH DIVERSIONS EQUALING OR EXCEEDING 100%	95%	90%	75%	50%	25%	>0%	PERCENTAGE OF YEARS PERCENTAGE OF TARGET DIVERSION AMOUNT 100%	98%	95%	90%	75%	50%	>0%
PK	254800.0	10135.51	94.54	96.02	94.5	94.7	94.8	94.8	95.4	96.4	100.0	82.8	82.8	84.5	87.9	94.8	98.3	100.0
Whitney	18000.0	958.69	94.68	94.67	94.7	94.7	94.7	94.7	94.8	95.0	100.0	82.8	82.8	82.8	84.5	89.7	94.8	100.0
WacoLake	80800.0	0.00	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Belton	180260.0	11917.84	91.67	93.39	91.7	91.8	92.0	92.4	92.5	93.7	100.0	82.8	82.8	86.2	86.2	87.9	93.1	100.0
George	25610.0	4721.70	76.29	81.56	76.3	76.6	77.2	78.4	80.7	83.3	100.0	50.0	53.4	60.3	63.8	70.7	79.3	100.0
Granger	42000.0	4140.04	85.78	90.14	85.8	85.9	86.5	87.4	90.4	92.8	100.0	60.3	62.1	70.7	79.3	86.2	91.4	100.0
Cameron	209600.0	34236.55	79.89	83.67	79.9	80.7	81.3	84.5	90.8	96.0	100.0	15.5	17.2	25.9	43.1	79.3	91.4	100.0
WacoGage	32300.0	2071.38	95.98	93.59	96.0	96.1	96.3	96.6	96.8	96.8	100.0	69.0	74.1	75.9	84.5	86.2	96.6	100.0
Highbank	44800.0	3629.86	95.83	91.90	95.8	95.8	95.8	96.0	96.6	97.1	100.0	69.0	70.7	72.4	77.6	86.2	93.1	100.0
Total	888170.0	71811.56		91.91														

END-OF-PERIOD RESERVOIR STORAGE AS A PERCENTAGE OF CAPACITY

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          Percentage = 100% * (S - C2) / (C1 - C2)   where
                   S = end-of-month storage
               C1,C2 = user defined top and bottom of storage zone
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YEAR	MONTH	MEAN	PK	Whit	WacoL	Belton	George	Grang
1940	1	95.39	87.31	99.72	97.44	96.35	95.13	96.40
1940	2	93.38	86.27	90.67	95.47	94.41	94.64	98.83
1940	3	76.51	82.16	79.71	91.85	91.32	90.61	23.42
1940	4	81.27	80.95	81.06	100.00	94.82	96.70	34.07
1940	5	85.09	96.14	79.87	94.87	92.20	100.00	47.48
1940	6	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1940	7	99.25	100.00	95.51	100.00	100.00	100.00	100.00
1940	8	96.14	100.00	100.00	92.36	94.09	94.45	95.96
1940	9	88.53	86.86	100.00	87.16	89.41	87.47	80.29
1940	10	68.44	82.41	89.49	83.46	78.57	-0.65	77.33
1940	11	96.92	93.50	100.00	100.00	100.00	88.00	100.00
1940	12	99.90	99.41	100.00	100.00	100.00	100.00	100.00
1941	1	99.72	98.33	100.00	100.00	100.00	100.00	100.00
1941	2	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1941	3	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1941	4	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1941	5	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1941	6	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1941	7	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1941	8	98.63	100.00	100.00	100.00	100.00	95.00	96.76
1941	9	96.41	100.00	100.00	96.34	100.00	89.34	92.80
1941	10	97.16	100.00	100.00	93.74	100.00	90.67	98.56
1941	11	96.41	100.00	100.00	93.88	100.00	87.48	97.13
1941	12	96.07	100.00	100.00	93.97	100.00	85.25	97.17
1942	1	96.16	100.00	99.01	99.53	99.57	82.64	96.19
1942	2	93.91	98.97	91.81	99.45	98.86	79.75	94.65
1942	3	89.98	97.24	82.28	98.54	93.55	76.07	92.19
1942	4	99.89	100.00	100.00	100.00	100.00	99.33	100.00
1942	5	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1942	6	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1942	7	91.61	95.42	76.59	98.26	89.17	93.96	96.28
1942	8	84.72	79.21	78.32	97.84	90.00	86.81	76.15
1942	9	95.13	100.00	91.63	100.00	100.00	92.11	87.05
1942	10	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1942	11	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1942	12	99.93	99.99	99.59	100.00	100.00	100.00	100.00
1943	1	98.54	99.82	91.39	100.00	100.00	100.00	100.00
1943	2	96.88	97.99	86.04	97.99	100.00	99.24	100.00
1943	3	97.93	99.10	92.39	97.29	100.00	98.80	100.00
1943	4	99.43	100.00	100.00	100.00	100.00	96.83	99.74
1943	5	98.90	98.13	100.00	100.00	100.00	95.25	100.00
1943	6	95.19	100.00	100.00	94.41	94.94	87.80	93.98
1943	7	85.92	75.74	94.40	88.47	88.10	80.34	88.46
1943	8	70.36	68.90	62.60	81.24	57.66	71.50	80.23
1943	9	56.13	63.75	52.90	81.27	55.26	64.87	18.71
1943	10	51.38	59.17	42.34	79.63	53.09	58.81	15.25
1943	11	47.15	49.19	40.44	76.64	50.51	53.82	12.30
1943	12	35.25	46.48	32.75	75.14	48.17	-0.65	9.59

RESERVOIR STORAGE DRAWDOWN DURATION

NAME	MEAN STORAGE (AC-FT)	BOTTOM OF ZONE (AC-FT)	TOP OF ZONE (AC-FT)	NUMBER OF PERIODS WITH DRAWDOWNS EQUALING OR EXCEEDING PERCENT OF ZONE STORAGE CAPACITY								
				0%	2%	5%	10%	25%	50%	75%	90%	100%
PK	382645.31	0.	570240.	696.	541.	498.	463.	351.	189.	91.	69.	48.
Whit	545640.81	379000.	627100.	696.	478.	451.	406.	320.	205.	122.	84.	53.
WacoL	170128.28	580.	192100.	696.	403.	360.	274.	114.	22.	0.	0.	0.
Belton	273197.97	0.	457600.	696.	528.	508.	474.	376.	276.	168.	104.	63.
George	18424.21	240.	37100.	696.	544.	519.	486.	412.	339.	288.	235.	181.
Grang	37312.72	220.	65500.	696.	473.	455.	432.	383.	299.	221.	168.	119.

RESERVOIR STORAGE RELIABILITY

NAME	MEAN STORAGE (AC-FT)	BOTTOM OF ZONE (AC-FT)	TOP OF ZONE (AC-FT)	PERCENTAGE OF MONTHS WITH STORAGE EQUALING OR EXCEEDING PERCENTAGE OF STORAGE CAPACITY								
				100%	98%	95%	90%	75%	50%	25%	10%	>0%
PK	382645.31	0.	570240.	18.8	22.3	28.4	33.5	49.6	72.8	86.9	90.1	100.0
Whit	545640.81	379000.	627100.	28.7	31.3	35.2	41.7	54.0	70.5	82.5	87.9	95.5
WacoL	170128.28	580.	192100.	37.5	42.1	48.3	60.6	83.6	96.8	100.0	100.0	100.0
Belton	273197.97	0.	457600.	21.6	24.1	27.0	31.9	46.0	60.3	75.9	85.1	100.0
George	18424.21	240.	37100.	20.1	21.8	25.4	30.2	40.8	51.3	58.6	66.2	74.0
Grang	37312.72	220.	65500.	30.2	32.0	34.6	37.9	45.0	57.0	68.2	75.9	82.9

ANNUAL SUMMARY TABLE FOR CONTROL POINT Belton

YEAR	NATURALIZED STREAMFLOW (AC-FT)	RETURN FLOW (AC-FT)	STREAMFLOW DEPLETION (AC-FT)	UNAPPROPRIATED FLOW (AC-FT)	EOP STORAGE (AC-FT)	EVAPORATION (AC-FT)	REGULATED STREAMFLOW (AC-FT)	ACTUAL DIVERSION (AC-FT)	DIVERSION SHORTAGE (AC-FT)
1940	595145.0	0.0	252957.9	342187.1	457600.0	19868.4	395016.3	180260.0	0.0
1941	1529345.0	0.0	197776.7	1308464.5	457600.0	17516.7	1331568.4	180260.0	0.0
1942	1233334.0	0.0	265270.9	968063.1	457600.0	21799.5	1031274.3	180260.0	0.0
1943	146944.0	0.0	111958.8	34985.2	220420.5	31496.5	172367.2	180260.0	0.0
1944	1079431.0	0.0	413675.6	665755.2	293726.5	19862.2	806002.8	180260.0	0.0
1945	1115511.0	0.0	368704.2	745699.3	457600.0	24570.5	746806.8	180260.0	0.0
1946	626618.0	0.0	189315.3	437302.7	416637.6	23658.7	463661.7	180260.0	0.0
1947	311816.0	0.0	141417.5	170398.5	270962.8	33140.6	244090.3	180260.0	0.0
1948	109094.0	0.0	107972.0	0.0	8117.6	23673.8	168005.5	180260.0	0.0
1949	311224.0	0.0	309501.0	0.0	91748.6	14131.4	39951.7	173510.0	6750.0
1950	152296.0	0.0	152296.0	0.0	25378.7	11459.4	26946.6	180260.0	0.0
1951	50375.0	0.0	50246.0	0.0	0.0	679.4	6966.7	68107.7	112152.3
1952	134356.0	0.0	134356.0	0.0	6241.0	2129.5	37012.5	88972.9	91287.1
1953	245643.0	0.0	240913.0	0.0	24.1	5126.5	74958.2	171775.1	8484.9
1954	23634.0	0.0	23634.0	0.0	0.0	0.2	0.0	23657.8	156602.2
1955	181309.0	0.0	162591.0	0.0	0.0	2743.5	47446.2	131119.1	49140.9
1956	153321.0	0.0	148010.7	0.0	0.0	6824.2	56417.8	90078.9	90181.1
1957	1375697.0	0.0	715237.9	642767.2	457600.0	9246.4	748378.4	160472.4	19787.6
1958	515526.0	0.0	98053.7	417472.3	346607.5	19180.1	427078.6	180260.0	0.0
1959	604987.0	0.0	363373.7	241613.3	457600.0	7744.3	305990.4	180260.0	0.0
1960	518033.0	0.0	226296.1	291736.8	457600.0	17308.1	320465.1	180260.0	0.0
1961	998165.0	0.0	197228.4	800936.6	457600.0	16968.3	800936.6	180260.0	0.0
1962	184661.0	0.0	182642.0	2019.0	420134.4	30241.4	11625.3	180260.0	0.0
1963	99203.0	0.0	92453.8	0.0	127332.5	32739.3	179005.7	180260.0	0.0
1964	420760.0	0.0	401209.0	0.0	151252.3	2317.6	214262.7	180260.0	0.0
1965	1090451.0	0.0	577963.1	499866.1	413159.9	6704.7	641578.5	180260.0	0.0
1966	460421.0	0.0	279483.3	179230.3	391271.5	25549.7	276499.6	180260.0	0.0
1967	102522.0	0.0	87427.0	0.0	112441.9	21752.6	179338.8	180260.0	0.0
1968	996422.0	0.0	461221.5	535200.5	361679.1	2236.9	564687.9	180260.0	0.0
1969	337292.0	0.0	242395.1	94896.9	355290.3	23682.3	139738.6	180260.0	0.0
1970	552204.0	0.0	240788.1	311415.9	293786.6	17416.9	416030.8	180260.0	0.0
1971	347779.0	0.0	347779.0	0.0	221133.1	11695.5	228477.1	180260.0	0.0
1972	138655.0	0.0	133788.0	0.0	32330.7	13210.5	133986.9	180260.0	0.0
1973	334417.0	0.0	334417.0	0.0	180684.0	5803.9	0.0	180260.0	0.0
1974	448618.0	0.0	448618.0	0.0	433021.1	5961.4	10059.4	180260.0	0.0
1975	527356.0	0.0	137881.6	389474.4	377340.9	13301.8	389474.4	180260.0	0.0
1976	307487.0	0.0	279562.0	27925.0	452088.9	3050.0	49429.0	180260.0	0.0
1977	610897.0	0.0	102727.4	508169.6	200156.2	24431.5	658138.2	180260.0	0.0
1978	25979.0	0.0	25286.0	0.0	0.0	4567.0	113363.9	108204.3	72055.7
1979	429184.0	0.0	429184.0	0.0	245659.8	3264.2	0.0	180260.0	0.0
1980	196118.0	0.0	195192.0	0.0	115214.2	18790.1	127513.5	180260.0	0.0
1981	236556.0	0.0	236556.0	0.0	168921.0	2589.2	0.0	180260.0	0.0
1982	189251.0	0.0	189251.0	0.0	162998.0	14914.1	0.0	180260.0	0.0
1983	85403.0	0.0	85403.0	0.0	44109.4	6088.4	17943.4	180260.0	0.0
1984	93522.0	0.0	92741.1	0.0	29644.4	373.2	12146.9	95466.8	84793.2
1985	318591.0	0.0	317376.0	0.0	161511.8	5248.7	1215.0	180260.0	0.0
1986	704113.0	0.0	581772.1	119437.6	457600.0	-1454.0	229218.9	180260.0	0.0
1987	645092.0	0.0	137390.5	507701.5	387807.4	21687.4	512937.4	180260.0	0.0
1988	119299.0	0.0	114999.0	0.0	5829.0	19044.6	301972.7	180260.0	0.0
1989	358252.0	0.0	358252.0	0.0	138260.6	13782.3	31778.1	180260.0	0.0
1990	783076.0	0.0	504392.6	270600.5	322526.2	16902.2	401648.0	180260.0	0.0
1991	841787.0	0.0	314500.4	527286.6	457600.0	-833.4	527286.6	180260.0	0.0
1992	1658040.0	0.0	180239.7	1477800.4	457600.0	-20.3	1477800.4	180260.0	0.0
1993	557804.0	0.0	152444.7	405359.3	379275.4	23457.9	432410.5	180260.0	0.0
1994	436073.0	0.0	290639.2	145433.8	341384.6	16803.9	276900.1	180260.0	0.0
1995	735896.0	0.0	369201.0	347008.5	419013.2	13586.2	464421.0	180260.0	0.0
1996	303148.0	0.0	294380.3	0.0	189501.5	15235.8	337163.8	180260.0	0.0
1997	1616768.0	0.0	475442.7	1141325.2	457600.0	8124.1	1160285.5	180260.0	0.0
MEAN	505256.9	0.0	251134.2	250992.0	255272.8	13299.6	323615.2	168342.2	11917.8

ANNUAL SUMMARY TABLE FOR THE RIVER BASIN

Note: For naturalized streamflow and unappropriated flow, the quantities shown represent the maximum flow at any control point in a given month, based on comparing all control points. All other quantities shown are the sum of the values for all the control points.

YEAR	NATURALIZED STREAMFLOW (AC-FT)	RETURN FLOW (AC-FT)	STREAMFLOW DEPLETION (AC-FT)	UNAPPROPRIATED FLOW (AC-FT)	EOP STORAGE (AC-FT)	EVAPORATION (AC-FT)	TARGET DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	DIVERSION SHORTAGE (AC-FT)
1940	7206145.0	442999.7	2503575.8	5124634.0	1946249.9	145304.0	2106770.0	2090157.8	16612.2
1941	12166396.0	571379.3	2537522.8	10139185.0	1930809.5	110783.3	2106770.0	2106770.0	0.0
1942	8083874.0	529867.4	2564310.5	6056804.0	1948540.0	140517.5	2106770.0	2093289.2	13480.7
1943	1751645.0	496656.5	1708109.5	467854.1	1096695.0	217111.1	2106770.0	2034559.6	72210.4
1944	8375878.0	612346.2	2770495.0	6214051.5	1239132.1	130017.0	2106770.0	2100162.8	6607.2
1945	9637853.0	602003.9	3225929.0	7035520.0	1844148.9	150050.7	2106770.0	2106770.0	0.0
1946	7831470.0	492781.6	2549283.5	5750685.5	1866074.2	160297.8	2106770.0	2071023.9	35746.1
1947	4570362.0	511971.2	2084358.0	2936527.5	1356289.6	210785.4	2106770.0	2075099.9	31670.2
1948	1670882.0	381898.0	1752511.2	253954.7	700072.4	194997.1	2106770.0	1983835.2	122934.7
1949	4142030.0	438183.2	2740620.0	1870864.1	1060127.0	122027.4	2106770.0	2001263.2	105506.8
1950	3664861.0	372732.0	2468481.0	1566782.8	1161681.0	159197.3	2106770.0	2029792.2	76977.8
1951	927895.0	207154.5	1065937.5	5827.7	583537.9	129289.8	2106770.0	1357569.5	749200.4
1952	1459278.0	374244.2	1437210.8	327357.4	544424.7	79352.4	2106770.0	1160975.9	945794.1
1953	4230387.0	329420.8	2358430.2	2219612.2	773883.4	79953.9	2106770.0	1898748.8	208021.3
1954	1180487.0	149929.1	1283082.8	32081.5	479942.3	120872.0	2106770.0	1347351.0	759418.9
1955	3002940.0	225593.0	2632897.2	463274.4	1163876.6	101088.6	2106770.0	1743900.0	362870.1
1956	907997.0	305820.1	1101726.5	40260.5	539440.1	148296.3	2106770.0	1335615.0	771155.0
1957	13753424.0	514339.8	3759419.0	10629114.0	1946730.2	37460.7	2106770.0	2000903.4	105866.7
1958	5447005.0	499379.0	2126898.0	3755024.0	1591261.0	106215.5	2106770.0	2095374.5	11395.5
1959	5265652.0	481654.0	2767898.8	2961404.8	1935312.0	59100.3	2106770.0	2082955.4	23814.7
1960	6216926.0	456312.2	2457613.0	4170459.5	1949640.0	117442.4	2106770.0	2074488.9	32281.1
1961	8427014.0	567251.1	2502585.0	6458586.0	1942874.9	68586.4	2106770.0	2106770.0	0.0
1962	3064613.0	426532.0	2339845.8	1104889.6	1860096.2	135246.8	2106770.0	2081007.6	25762.4
1963	1401564.0	360858.2	1409602.8	284525.5	926391.2	178605.0	2106770.0	1957670.5	149099.4
1964	1916833.0	523481.3	2185348.8	229639.6	825665.5	72214.9	2106770.0	1870494.1	236275.9
1965	7868382.0	610943.4	3223252.5	5285892.5	1472439.4	76193.6	2106770.0	2106225.8	544.2
1966	5672785.0	575178.4	2811299.8	3453430.5	1723869.8	125574.6	2106770.0	2078035.0	28735.0
1967	1627047.0	327353.1	1651589.9	259418.0	1128082.5	132096.5	2106770.0	1924909.1	181860.8
1968	10027578.0	595881.7	3001816.0	7636649.5	1601437.5	60910.5	2106770.0	2102426.2	4343.7
1969	5660009.0	476861.9	2552817.8	3588945.0	1685824.6	120480.3	2106770.0	2063440.8	43329.3
1970	4547380.0	526181.3	2134152.5	2889463.0	1291082.9	148532.8	2106770.0	2054079.5	52690.4
1971	2831197.0	452031.7	2577844.2	684931.8	1473826.2	92487.3	2106770.0	2016919.0	89851.0
1972	2288953.0	362922.0	2026373.6	578201.0	1192824.9	132104.8	2106770.0	1962109.2	144660.7
1973	7788790.0	528951.0	2804370.8	5523129.5	1542162.0	55659.8	2106770.0	2094911.5	11858.5
1974	6439932.0	454707.6	2777692.8	4154251.0	1925061.1	98028.3	2106770.0	2032059.2	74710.8
1975	6280926.0	598136.1	2234190.0	4581978.0	1583170.4	109403.1	2106770.0	2106770.0	0.0
1976	5635648.0	594113.1	2736894.2	3484549.5	1783205.5	59688.0	2106770.0	2103941.8	2828.2
1977	5798091.0	484106.6	1759908.0	4457091.0	1061849.6	147796.9	2106770.0	2035793.8	70976.2
1978	1860528.0	346578.2	1808062.4	237858.0	756012.4	90540.4	2106770.0	1793603.8	313166.3
1979	7763266.0	607801.6	3059519.2	5314571.5	1264751.2	63882.6	2106770.0	2106770.0	0.0
1980	3154210.0	387542.5	2005792.2	1461394.9	976011.9	124872.0	2106770.0	1948406.0	158364.0
1981	5483804.0	523839.5	3120924.8	2931962.0	1622854.9	44773.2	2106770.0	2099819.2	6950.7
1982	3932170.0	432567.9	1922474.1	2430519.8	1126124.5	105039.6	2106770.0	2071303.5	35466.5
1983	3397673.0	495214.0	1956230.4	1879720.6	673108.2	79182.3	2106770.0	2050313.1	56456.9
1984	2788740.0	204724.7	1443545.5	1494722.8	852178.7	51288.4	2106770.0	1106327.0	1000442.9
1985	5128397.0	408281.8	2754464.5	2814227.5	1316747.8	94826.6	2106770.0	1965287.8	141482.2
1986	6473233.0	538791.9	3084350.0	3965670.2	1937434.1	59094.7	2106770.0	2075977.9	30792.2
1987	6630168.0	576152.2	2180626.5	4977291.5	1566908.8	93843.2	2106770.0	2106770.0	0.0
1988	1199118.0	410057.3	1336550.6	181605.4	541527.6	117147.0	2106770.0	2009963.9	96806.1
1989	4485307.0	487020.1	2887390.0	2122913.8	1005411.9	82685.7	2106770.0	2050958.5	55811.5
1990	6402781.0	448375.3	2884640.5	4039967.8	1454984.1	78111.2	2106770.0	2072519.9	34250.1
1991	10357707.0	443167.5	2861946.2	7971517.0	1949640.0	49684.0	2106770.0	2083593.2	23176.8
1992	14828370.0	597150.8	2405094.8	12974243.0	1814286.1	71235.5	2106770.0	2106770.0	0.0
1993	6240506.0	566839.1	2355592.2	4399041.5	1597125.8	138339.7	2106770.0	2087470.0	19300.0
1994	5097575.0	489612.1	2445838.0	3099138.5	1611930.2	93230.6	2106770.0	2035886.0	70883.9
1995	5830484.0	563936.6	2616484.8	3762983.5	1716043.6	72559.3	2106770.0	2102145.2	4624.8
1996	2273891.0	438682.7	2142542.5	482779.8	1502186.9	114700.1	2106770.0	1947921.1	158848.9
1997	10113623.0	597666.7	2786084.0	7917001.5	1758543.5	55886.4	2106770.0	2106770.0	0.0
MEAN	5382961.5	465968.2	2356621.8	3467861.2	1374509.4	107149.8	2106768.5	1972702.2	134067.5

Appendix C − SIM Input Records

Format specifications found in the 4th column of the record description tables are defined as follows:

- A6 − alphanumeric label in a field that is 6 characters wide
- 2x − skip two spaces (Fields with the spacing descriptor x are not read.)
- F8.0 − real number in field of 8 characters with any number of digits to the right of the decimal (Either include decimal or right justify the number.)
- 5F8.0− five real numbers, each having a F8.0 specification
- I8 − integer number right justified in field of 8 characters (Decimal is not allowed.)
- 3I8 − three integer numbers with each right justified in field of 8 characters

T1, T2, and **T3** Records – Titles or Headings

field	columns	variable	format	value	description
1	1-2	CD	A2	T1,T2,T3	Record identifier
2	3-78	TITLE	A78	AN	Title or heading

The *SIM* DAT file normally begins with a *T1* record that optionally may be followed by *T2* and *T3* records. The headings provided by the one to three title records are printed at the beginning of the *SIM* output file and on the *TABLES* cover page.

** Record – Comments

field	columns	Variable	format	value	description
1	1-2	CD	A2	**	Record identifier
2	3-no limit			AN	Comments which are not read by the program

A record beginning with ** is not read by the program, except for the ** identifier. ** records are used to insert notes in the input dataset or to temporarily deactivate selected records.

ED Record – End of Data

field	columns	variable	format	value	description
1	1-2	CD	A2	ED	Record identifier

The *ED* record ends both the DAT and DIS files.

JD Record – Simulation Job Control Data

field	columns	variable	format	value	description
1	1-2	CD	A2	JD	Record identifier
2	3-8	NYRS	I6	+	Number of years in the simulation period-of-analysis.
3	9-16	YRST	I8	+	First year of simulation. All *IN* and *EV* records before year YRST will be skipped.
					Level of Error Checks
4	24	ICHECK	I8	–1	Minimal trace messages and reduced error checks
				blank,0	Normal trace and reduced error checks
				1	Normal error checks and input trace
				2	*UC* and *RF* records are copied to MSS file.
				3	*CP* records are copied to MSS file.
				4	*WR/IF* records are copied to MSS file.
				5	*SV/SA* records are copied to MSS file.
				6	*IN/EV* records are copied to MSS file.
				7	*FD/FC/WP* records are copied to MSS file.
				8	Write DUAL simulation information.
				9	Warning messages are deactivated.
					Data Written to OUT Output File
5	31-32	CPOUT	I8	–1	Control point data is output for all control points.
				–2	Control point data is output only for cp's with *IN* records plus those cp's listed on *CO* records.
				+	Control point output is limited to first CPOUT control points plus those cp's listed on *CO* records.
				blank,0	Control point output is specified only by CO records, with no CP output without a *CO* record.
6	39-40	OUTWR	I8	–1	Water rights data is output for all *WR* and *IF* record rights except hydropower rights.
				–2	All *WR* and *IF* record rights including hydropower.
				–3	Non-hydropower *WR* record rights.
				–4	Instream flow (*IF* record) rights.
				+	Water right output is limited to first OUTWR rights in input file plus those listed on *WO* and *GO* records.
				blank,0	Water rights output is specified by *WO* and/or *GO* records, with no wr output without these records.
7	48	IDSET	I8	blank,0,1	First set of identifiers on *WR* input records are used.
				2	Second set of identifiers on *WR* records are used.
					Negative Incremental Naturalized Flow Options
8	56	ADJINC	I8	blank,0,1	Option 1 - No adjustments are performed.
				2	Option 2 – Downstream flow adjustments.
				3	Option 3 - Upstream adjustments applied at all cp's.
				–3	Option 3 with secondary control points excluded.
				4	Option 4 - Adjustment only at cp of the water right.
				–4	Option 4 with secondary control points excluded.
				5	Option 5 – Alternative simulation approach.

JD Record – Simulation Job Control Data (Continued)

field	columns	variable	format	value	description
					Negative Incremental Flow Adjustments to MSS File
9	64	NEGINC	I8	blank,0,1	No adjustments written.
				2	Downstream adjustments written to MSS file.
				3	Upstream adjustments written to MSS file.
					Set Default for Evap-Precip Adjustment
10	72	EPADJ	I8	blank,0	No adjustment unless specified on *CP* record
				–1	Adjustments based on ungaged CP (*FD* field 2)
				–2	Adjustments based on gaged CP (*FD* record field 3)

The *JD* record follows the *T1*, *T2*, *T3* records. Fields 1, 2, and 3 (*CD*, *NYRS*, *YRST*) are the only required entries. All other fields are left blank unless the options activated by each field are needed. The optional *JO* record normally follows immediately behind the required *JD* record.

JO Record – Simulation Job Options

field	columns	variable	format	value	description
1	1-2	CD	A2	JO	Record identifier
					Organization of IN and EV Records
2	8	INEV	I6	blank,0,1	Grouped by years in FLO and EVA files.
				−1	Grouped by years in FLO file. No EVA file.
				2	Grouped by control points in FLO and EVA files.
				−	Grouped by control points in FLO file. No EVA file.
				3	Grouped by years in DAT file.
				4	Grouped by control points in DAT file.
				5	Grouped by years in HYD file in HYD file format.

The seven other JO record fields are described in the Users Manual.

FY Record – Firm Yield and Yield-Reliability Table

field	columns	variable	format	value	description
1	1-2	CD	A2	FY	Record identifier
2	3-8	FYIN(1)	F6.0	+	Fraction (0.0-1.0) of monthly target that must be met in order to not count the month a failure in meeting the target in the period reliability computations.
				Blank,0	Default = 1.0
3	9-16	FYIN(2)	F8.0	+	Initial value for the annual target amount. (Must be greater than zero.)
4	10-24	FYIN(3)	F8.0	+	Incremental decrease for first level of decreases for iterative simulations. (Must be greater than zero.)
5	25-32	FYIN(4)	F8.0	+	Incremental decrease for second level of decreases.
				blank,0	Optional second level is not used.
6	33-40	FYIN(5)	F8.0	+	Incremental decrease for third level of decreases.
				blank,0	Optional third and fourth levels are not used.
7	41-56	FYWRID	A16	AN	Water right identifier for *FY* record rights.
8	57-64	FYGROUP	A8	AN	Water right group identifier for *FY* record rights.
9	65-72	MFY	I8	blank,0,1	Proportional to amounts in *WR* record field 3.
				2	Based on priorities in *WR* record field 5.
10	73-80	SIM3	I8	blank,0	Simulation results are not written to root.OUT file.
				+,–	Results for final iteration are written to OUT file.

The *FY* record activates the yield-reliability analysis. The optional *FY* record is placed between the *JD*/*JO* records and *UC* records.

CO Record – Control Point Output Records to be Included in Output File

field	columns	variable	format	value	description
1	1-2	CD	A2	CO	Record identifier
2	7-8	NCPOUT	I6	+	Number of control point identifiers listed on *CO* records. NCPOUT is entered only on first *CO* record. Field 2 should always be blank on the second and subsequent *CO* records.
				blank,0	*CO* records are ignored if NCPOUT is zero.
3-7	9-48	CPOUID(J) J=1,5	5(2x,A6)	AN	Control point identifiers. Output records for cp's with these identifiers will be included in output file.

RO Record – Reservoir Output Records to be Included in Output File

field	columns	variable	format	value	description
1	1-2	CD	A2	RO	record identifier
2	7-8	NREOUT	I6	+	Number of reservoir identifiers listed on *RO* records. NREOUT is entered only on first *RO* record. Field 2 should always be blank on the second and subsequent *RO* records.
				–1	All reservoirs are included in output.
				blank,0	*RO* records are ignored if NREOUT is zero.
3-7	9-48	REOUID(J) J=1,5	5(2x,A6)	AN	Reservoir identifiers. Output records for reservoirs with these identifiers will be included in output file.

The optional *CO*, *RO*, *WO*, and *GO* records are placed as a group between the *JD/JO* records and *UC* records. All *CO* records are grouped together. All *RO* records are grouped as a set. Likewise, all *WO* are grouped together, and all *GO* records are grouped together. It does not matter which of the four sets of records precede or follow the others. All are optional. The *CO*, *RO*, *WO*, and *GO* records are all organized in the same way.

The *CO*, *RO*, *WO*, and *GO* records are used along with *JD* record fields 5-7 to select data to include in the simulation results written to the OUT file. For each, any number of identifiers may be provided on any number of records, with five identifiers per record. However, no more than one CO, one RO, one WO, and one GO record can be used to specify in field 2 the number of control points, reservoirs, water rights or water right groups, respectively, to include. For example, 53 control point identifiers would be listed on 11 *CO* records with five identifiers on each of ten records and three on the 11th record. The integer 53 would be entered in field 2 of the first *CO* record.

WO Record – Water Rights Output Records to be Included in Output File

field	columns	variable	format	value	description
1	1-2	CD	A2	WO	Record identifier
2	7-8	NWOUT	I6	+	Number of water rights identifiers listed on *WO* records. NWOUT is entered only on first WO record. Field 2 should always be blank on the second and subsequent *WO* records.
				blank,0	*WO* records are ignored if NWOUT is zero.
3-7	9-88	WROUT(J) J=1,5	5A16	AN	Water right identifiers. Water right output records for rights with these identifiers will be included in output.

GO Record – Groups of Water Rights Output Records to be Included in Output File

field	columns	variable	format	value	description
1	1-2	CD	A2	GO	Record identifier
2	7-8	NGOUT	I6	+	Number of water rights identifiers listed on *GO* records. NGOUT is entered only on first *G*O record. Field 2 should always be blank on the second and subsequent *GO* records.
				blank,0	*GO* records are ignored if NGOUT is zero.
3-7	9-48	GROUP(J) J=1,5	5A8	AN	Water right identifiers. Water right output records for rights with these identifiers will be included in output.

Two sets of three optional water rights identifiers are provided in fields 11-16 of the *WR* record. Only one of the two sets of three identifiers are read by *WRAP-SIM*. The selection of which of the two sets to use is specified by *IDSET* in field 8 of the *JD* record. Water rights output records are selected by matching the identifiers on the *WO* record with the first identifier on the *WR* records and matching the *GO* record group identifiers with the second and third identifiers on the *WR* records.

UC Record – Water Use Coefficients

field	columns	variable	format	value	description
1	1-2	CD	A2	UC	Record identifier
2	3-8	USEID	A6	AN	Identifier relates sets of use factors to the use type in field 4 of *WR* and *IF* records.
3-14	9-104	PDUSCF	12F8.0	+	Monthly water use coefficients for the 12 months.

A *UC* record with 12 coefficients or a pair of *UC* records with six coefficients each is provided for each water use type. The two alternative forms of *UC* records are the same except for the number of coefficients included on each record.

The use identifier in field 2 of the *UC* record corresponds to the use identifier in field 4 of the *WR* and *IF* records. The set of 12 monthly factors is used to distribute an annual diversion, instream flow, or hydroelectric energy requirement over the 12 months of the year. *SIM* divides each monthly coefficient by the sum of the 12 coefficients to obtain a set of 12 monthly multipliers.

CP Record – Control Point Information

field	Columns	variable	format	value	description
1	1-2	CD	A2	CP	Record identifier
2	3-8	CPID(cp,1)	A6	AN	Control point identifier [cp = 1,NCPTS]
3	11-16	CPID(cp,2)	2x,A6	AN	Identifier of next downstream control point.
				blank,OUT	Basin outlet. There is no control point downstream.
					Multiplier Factors
4	17-24	CPDT(cp,1)	F8.0	+	Factor by which inflows on IN records are multiplied
				blank,0	Default factor = 1.0
5	25-32	CPDT(cp,2)	F8.0	+	Factor by which evaporation rates are multiplied
				blank,0	Default factor = 1.0
					Method for Obtaining Naturalized Flows
6	40	INMETHOD (cp)	I8	0,1	IN records are input for this control point.
				2	Specifications are provided by *CPIN(cp)* in field 7.
				3	Flow distribution equation is used.
				4	NRCS CN method with synthesized flows limited to not exceed source control point flows
				5	NRCS CN method without above noted flow limit
				6	Channel loss coefficient with DAR method
				7	Drainage area ratio method (areas from *WP* records)
				8	NRCS CN method with channel losses
7	43-48	CPIN(cp)	2x,A6	AN	Control point from which *IN* records are repeated
				NONE ZERO	The words *none, zero, NONE, or ZERO* indicate zero streamflows at this control point.
					Method for Obtaining Net Evaporation-Precipitation
8	51-56	CPEV(cp)	2x,A6	blank	*EV* records are read as input.
				AN	Control point from which *EV* records are repeated
				NONE ZERO	The words *none, zero, NONE, or ZERO* in this field indicate zero net evaporation at this control point.
					Evaporation-Precipitation Adjustment
9	57-64	EWA(cp)	F8.0	blank,0	Default set by *JD* record field 10 is used.
				–1.0	Ungaged CP from *FD* record field 2 is used.
				–2.0	Gaged CP from *FD* record field 3 is used.
				–3.0, <–3.0	No adjustment. (Overrides non-blank *JD* field 10)
				+	Watershed area in acres for E-P adjustment.
					Channel Loss Factor
10	65-72	CL(cp)	F8.0	+	Channel loss factor for stream reach below CP.
				blank	The default channel loss factor value is 0.0.
					Watershed Areas on WP Records
11	73-80	INWS(cp)	I8	blank,0	Parameters on WP record are for the total watershed.
				+	Parameters on WP record are for incremental watersheds. (any positive integer)

Explanation of CP Record Fields

A *CP* record is required for each and every control point. The control points may be entered in any order, but all *CP* records must be grouped together separated by nothing except ** records.

Field 2.- The six alphanumeric character identifier of the control point is entered on various other types of records to designate location.

Field 3.- The control point located immediately downstream of each control point is designated in order for the model to delineate the spatial configuration of the river system.

Field 4, 5.- The naturalized flows from the *IN* records and net evaporation depths from *EV* records are multiplied by factors in fields 4 and 5 that could be unit conversions, drainage area ratios, or other factors.

Field 6.- Naturalized flows at a control point may be provided as input on *IN* records or synthesized within the model by optional methods selected by field 6.

Field 7.- The naturalized streamflows at a control point may repeated from those provided at another control point or set at zero.

Field 8.- The net evaporation-precipitation depths at a control point may repeated from those provided at another control point or set at zero.

Field 9.- A methodology described in Chapter 3 of the *Reference Manual* adjusts the evaporation-precipitation depths from the *EV* records for runoff from the land area covered by a reservoir that is reflected in the naturalized streamflows to prevent double-counting. *EWA(cp)* of -1 or -2 results in the runoff depth adjustment being computed by dividing the naturalized streamflow by watershed area as defined by *FD* records. For *EPADJ* = -1, the ungaged control point of *FD* record field 2 is used. For *EPADJ* = -2, the gaged control point in *FD* record field 3 record is used. For either option, the control point in field 2 of the *CP* record connects to the control point in field 2 of the *FD* record. However, for ungaged control points, the runoff depth computations may be based on flow/area at either the ungaged or gaged site.

EPADJ in *JD* record field 10 sets the default used to correct the evaporation-precipitation depths. The option specified in the *JD* record field 10 is used for all control points for which the *CP* record field 9 is blank [*EWA(cp)*=0]. *EWA(cp)* entered in field 9 of a *CP* record supersedes the default set in field 10 of the *JD* record.

Field 10.- The channel loss in a river reach is defined as the flow at the upstream control point multiplied by the channel loss factor entered in *CP* record field 10 for the upstream control point.

Field 11.- The drainage area, curve number, and mean precipitation provided on watershed parameter WP records in a DIS file are used to distribute flows from gaged to ungaged control points. *CP* record field 11 is used to indicate whether these watershed parameters are for the total watershed above the control point or incremental subwatersheds between control points. The default is total watersheds.

WR Record – Water Right

field	Columns	variable	format	value	description
1	1-2	CD	A2	WR	Record identifier
2	3-8	CP	A6	AN	Control point identifier
3	9-16	AMT	F8.0	0,+	Annual diversion or hydropower target
4	19-24	USE	2x,A6	AN	Use type identifier to connect to *UC* records
				blank	Default constant uniform distribution over the year
5	25-32	WRNUM(wr,7)	I8	–,0,+	Priority number
					Water Right Type
6	36	WRNUM (wr,5)	I4	blank,0,1	Type 1 water right
				2	Type 2 water right (no refilling storage)
				3	Type 3 water right (no streamflow depletions)
				4	Type 4 water right (inflow to stream)
				5, –1	Type 5 water right (hydroelectric power)
				6, –3	Type 6 water right (hydroelectric power)
					Return Flow Specifications
7	40	RFMETH (wr)	I4		Return flow method
				blank,0,1	Constant factor, flows returned same month
				2	Constant factor, flows returned next month
				3	Monthly factors, flows returned same month
				4	Monthly factors, flows returned next month
8	41-48	RFAC	F8.0	+	Constant return flow factor
		RFIDWR	2x,A6	AN	Identifier on RF record for monthly factors
9	51-56	RCP	2x,A6	blank	Flow returned to next downstream control point
				AN	Identifier of control point to return flow
					Drought Index
10	63-64	DINDEX(wr)	6x,I2	blank,0	Drought index is not used for this water right.
				+,–	Integer identifier (1,2,3,...,15) of drought index. If positive, the drought index is applied as step 3 outlined on page 33. A negative sign switches to applying the drought index as step 6 on page 34.
					First Set of Identifiers
11	65-80	WRID(wr)	A16	AN	Water right identifier
				blank	Option not used
12	81-88	WRIDS (wr,1)	A8	AN	Second water right identifier (group identifier)
				blank	Option not used
13	89-96	WRIDS (wr,2)	A8	AN	Third water right identifier (group identifier)
				blank	Option not used
					Alternate Set of Identifiers
14	97-112	WRID(wr)	A16	AN	Alternate water right identifier
				blank	Option not used
15	113-120	WRIDS (wr,1)	A8	AN	Alternate second water right identifier (group)
				blank	Option not used
16	121-128	WRIDS (wr,2)	A8	AN	Alternate third water right identifier (group)
				blank	Option not used

Explanation of WR Record Fields

Field 2: The water right has access to available streamflow at this control point. Diversions and streamflow depletions associated with the right occur at this control point.

Field 3: The annual volume/year water supply diversion target or annual hydropower energy generation target is used by *SIM* in setting the monthly target for each month at the beginning of the period computation loop. The annual target amount is multiplied by monthly distribution factors determined from *UC* records to determine monthly targets. These monthly targets may be further adjusted by options controlled by entries on the *DI*, *SO*, and *TO* records. The monthly targets represent a demand or water use requirement that is met subject to water availability.

Field 4: The water use identifier serves the sole purpose of connecting *WR* and *IF* records to *UC* and *UP* records. Any alphanumeric identifier of 6 characters or less may be used along with the two following special cases.

If *WR* or *IF* record field 4 is blank, the 12 monthly water use factors default to a uniform 1/12.

If the terms *NDAYS* is entered in *WR* or *IF* record field 4, the 12 factors otherwise read on the *UC* records are set at the number of days in each month starting with January (31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31). SIM divides these factors by their sum of 365 to obtain the monthly multiplier factors.

Field 5: The priority number is an integer reflecting relative priorities that governs the order in which water rights are considered in the simulation. A blank field 4 assigns a priority of zero, which is treated like any other integer number. The priority in field 4 may be over-ridden or adjusted by factors entered on the *UP* record. Priorities may also be replaced by the upstream-to-downstream natural priority option activated by *JO* record field 8.

Field 6: The water right type specifies rules for meeting water right requirements as described in Chapter 4 of the *Reference Manual*.

The default type 1 right allows a diversion target to be supplied from streamflow depletions and/or storage in one or more reservoirs. The diversion is met from streamflow to the extent that streamflow is available and then from storage. One primary reservoir can be refilled from streamflow depletions and releases from other system reservoirs. The diversion and primary reservoir must be at the control point indicated in field 2.

A type 2 right is identical to a type 1 right except reservoir storage is not refilled.
A type 5 right is identical to a type 1 right except hydroelectric power generation replaces the diversion target.

Field 7, 8, 9: All or a portion of the diversion may be returned to the river system at the same control point as the diversion or at any other control point. The optional methods are outlined in Chapter 3 of the *Reference Manual*.

Field 10: The drought index in field 10 assigns a set of *DI/IS/IP* records to the water right. The drought index in *WR* or *IF* record field 10 is the same as the *NDI* entered in *DI* record field 2.

Field 11-16: Water right identifiers are described in Chapter 2 of the *Users Manual*.

IF Record – Instream Flow Requirement

field	Columns	variable	format	value	description
1	1-2	CD	A2	IF	Record identifier
2	3-8	CP	A6	AN	Control point identifier
3	9-16	AMT	F8.0	+	Annual instream flow requirement
4	19-24	USE	2x,A6	AN	Use type identifier to connect to *UC* records
				blank	Default constant uniform distribution over the year
5	25-32	WRNUM(,7)	I8	–,0,+	Priority number
					Type of Instream Flow Computations
6	39-40	IFMETH (wr)	I8	blank,0,1	Constraints on water availability during first pass
				2	Constraints on water availability during second pass
				–2	Constraints during both first and second passes
				3	Constraints during first pass, reservoir storage used
				4	Constraints during second pass, reservoir storage
				–4	Constraints during both first and second passes
7	44	IFFLAG2 (wr)	I4	blank,0	Instream flow limit is based on total regulated flow.
				1,non-zero	Reservoir releases for downstream use are excluded.
					Drought Index
8	47-48	DINDEX(wr)	I4	blank,0	Drought index is not used for this water right.
				+,–	Integer identifier (1,2,3, ...) of drought index. If positive, the drought index is applied as step 3 outlined on page 33. A negative sign switches to applying the drought index as step 6 on page 34.
					Water Right Identifier
9	49-64	WRID(wr)	A16	AN	Water right identifier (optional)

The data entered in fields 1, 2, 3, 4, 5, 8, and 9 of the *IF* record are similar for both *IF* and *WR* record water rights. *IF* record fields 6 and 7 dealing specifically with instream flow right computations are discussed below.

Field 6 *IFMETH* options 1 and 2 constrain streamflow depletions by all junior rights to protect instream flow targets but do not require releases from storage. Options 3 and 4 result in releases from storage in reservoirs identified by *WS* records associated with the *IF* record to mitigate instream flow shortages.

IFMETH options other than options 1 and 3 exist for the sole purpose of partially mitigating the problem of (1) senior *WR*-record rights not having access to water made available by junior *WR*-record rights through either same-month option diversion return flows or same-month option hydropower releases and (2) the contribution of reservoir releases not being credited in meeting instream flow targets at intermediate control points between the dam and diversion site assuming

IFFLAG2 is zero (blank field 7). *IFMETH* options 1 and 3 should be used if this problem is not a concern and perhaps even if this problem is a concern. All of the other options involve a possible repeat of the simulation, which is called a second pass through the water rights computation loop. With *IFMETH* options 2 and 4, instream flow requirements are not activated during the first pass, and a second pass with instream flow requirements activated is performed if and only if at least one instream flow shortage occurs during the first pass. Options –2 and –4 mean that the instream flow requirements are activated for the first pass as well as second pass. *PASS2* in *JO* record field 7 forces a second pass in all months regardless of the *IF* record *IFMETH* option. With options 2 and 4, instream flow requirements are not reflected in unappropriated flows for months without a second pass.

WR and *IF* records may be in any order. The set of all *WR* and *IF* records, along with their supporting records, follow the set of all *CP* records. The set of records for each individual water right consists of a *WR* or *IF* record followed in any order by its optional *SO*, *DT*, *TO*, *ML*, *TS*, and/or *WS/HP/OR* records. The set of all of these types of supporting records associated with a particular water right must follow directly behind their *WR* or *IF* record.

WS Record – Reservoir Storage Associated with a Water Right

field	columns	variable	format	value	description
1	1-2	CD	A2	WS	Record identifier
2	3-8	RES	A6	AN	Reservoir identifier
3	9-16	WRSYS(sr,3)	F8.0	+	Total storage capacity at top of the conservation pool.
					Storage-Area Relationship
4	17-24	EVCFA	F8.0	+	Multiplier *A* for storage-area equation shown below.
5	25-32	EVCFB	F8.0	+	Exponent *B* for storage-area equation shown below.
6	33-40	EVCFC	F8.0	+	Constant *C* for storage-area equation shown below. $\text{surface area} = A\,(\text{storage})^{B} + C$ If fields 4, 5 & 6 are all blank, a table on *SV* & *SA* records is required to define the storage-area relation.
					Optional Storage Specifications
7	41-48	INACT	F8.0	+	Storage capacity at top of the inactive pool.
8	49-56	BEGIN	F8.0	Blank,0	Reservoir is full to capacity (field 3) at the beginning.
				+	Storage volume at the beginning of the simulation.
					Evaporation Allocation Reservoirs
9	57-64	IEAR	I8	Blank,0	Option not used.
				+	*EA* record identifier (1, 2, 3, ...). 1 for first *EA* record.
10	71-72	SA	I8	Blank,0	A separate storage-area relationship is provided.
				–1	Use *SV/SA* records for first reservoir on *EA* record.
					Downstream Versus Lakeside Diversions
11	79-80	LAKESD	I8	Blank,0	Water supply diversions are accessible to hydropower.
		= WRNUM(wr,11) or SN3(swr,sr)		–1	Lakeside diversions do not generate hydropower.

Multiple reservoirs may be associated with a single water right. A *WS* record is required for each reservoir associated with a right. The optional hydropower *HP* and operating rules *OR* records are connected to a particular *WS* record and follow directly after the *WS* record. A *HP* record follows directly behind its *WS* record. The *OR* record follows directly behind the *HP* record. If there is no *HP* record, the *OR* record follows directly behind the *WS* record. A set of *WS/HP/OR* may be placed anyplace in the group of supporting records that follow a *WR* or *IF* record.

Multiple rights may be associated with a particular reservoir. The total storage capacity in *WS* field 3, inactive storage capacity in field 7, and turbine/lakeside diversion switch in field 11 are connected to a water right and may vary with different rights at the same reservoir. Likewise, the parameters entered on *OR* records to define operating rules are associated with a particular water right and may vary between multiple rights at the same reservoir. Other data entered on *WS* and *HP* records are connected to a particular reservoir and are constant for that reservoir with no variation between multiple rights. After being entered with one right, these data do not have to be repeated for other rights at the same reservoir. Fixed reservoir data include *WS* fields 4, 5, 6 and *HP* fields 4, 5, 6. *SV/SA*, *PV/PE*, and *TQ/TE* record tables are also fixed for a reservoir.

Explanation of WS Record Fields

Field 3: A water right refills a reservoir to the storage capacity entered in field 3 subject to water availability. Multiple rights at the same reservoir may refill storage to various levels at different priorities. The conservation storage capacity for a junior right must equal or exceed the storage capacity associated with more senior rights at the same reservoir.

Fields 4, 5, 6: *WRAP-SIM* provides two options for inputting the storage volume versus surface area relationship for a reservoir: (1) a table provided on *SV* and *SA* records and (2) coefficients for the following equation provided in fields 4, 5, and 6 of the *WS* record:

$$\text{surface area} = A\,(\text{storage})^{B} + C$$

If *WS* record field 4 is blank, a pair of *SV/SA* records must be provided for the reservoir. For multiple rights associated with a particular reservoir, the storage-area input only has to be provided once, with the first right (*WR/IF* record) read. There is only one storage-area relationship for a reservoir even if the reservoir is associated with multiple water rights. Fields 4, 5, and 6 of the *WS* record is left blank if the storage-area information is specified elsewhere.

Field 7: Releases or withdrawals are curtailed whenever storage contents fall below the top of the inactive pool.

Field 8: The reservoir is assumed full to capacity (field 3) at the beginning of the first month of the first year of the simulation unless an initial storage is entered in *WS* record field 8 or the beginning-ending-storage feature is activated by *JO* record field 5.

Field 9: The integer identifier connects this reservoir to an *EA* record, used to define options for allocating net evaporation between component reservoirs used to model a multiple-owner reservoir. An *EA* record is needed only if the multiple owners have access to different amounts of storage capacity with different priorities in the same reservoir. An *EA* record is not needed for multiple owners with access to the same storage pool. The integer 1 in *WS* record field 9 links this reservoir to the first *EA* record in the input file, a 2 links to the second *EA* record, a 3 links to the third *EA* record, and so forth. There is no limit on the number of EA records that may be included in a dataset.

Field 10: The reservoirs listed on an *EA* record may share the storage-area table provided by the *SV/SA* records for the first reservoir listed, or each reservoir may have its own storage-area relationship. A negative integer for *SA* in field 15 indicates that since this reservoir is adopting the same *SV/SA* records as the first reservoir on its *EA* record, a separate storage-area relationship is not entered in either *WS* record fields 4, 5, 6 or as *SV/SA* records.

Field 11: Field 11 is used for a diversion right to flag whether the diversion is available later in the priority loop for junior hydropower rights. *LAKESD* specifies whether a water supply diversion is released through the turbines, incidentally generating hydroelectric energy, or withdrawn lakeside without being accessible for hydropower production. *WS* record field 11 is relevant only for a senior water supply diversion met by releases from a reservoir at which a hydroelectric power plant for a more junior hydropower right is also located.

HP Record – Hydroelectric Power

field	columns	variable	format	Value	description
1	1-2	CD	A2	HP	Record identifier
2	3-8	WRSYS(sr,4)	F6.0	Blank,0 +	Default efficiency = 0.85 Energy efficiency for hydroelectric power plant.
3	9-16	WRSYS(sr,1)	F8.0	Blank,0 +	Tailwater discharge-elevation from TQ/TE records. Constant tailwater elevation.
4	17-24	TELEV(res)	F8.0	Blank,0 +	Bottom power pool defined by INACT in WS field 7. Turbine inlet invert elevation.
5	25-32	TQCAP(res)	F8.0	Blank,0 +	No limit on turbine discharge. Turbine discharge capacity.
6	33-40	TPCAP(res)	F8.0	Blank,0 +	No limit on amount of secondary energy generated. Maximum limit on energy production.

A hydroelectric power right is activated by a water right type of 5 or 6 in *WR* record field 6. A *HP* record is placed immediately behind the corresponding *WS* record to provide hydropower parameters. A *HP* record is not required for a hydropower right if the default values are adopted for all of the hydropower parameters.

Explanation of HP Record Fields

Field 2: The efficiency is a fraction less than 1.0 representing the ratio of electrical energy to hydraulic energy used in the power equation. The default efficiency is 0.85.

Field 3: A constant tailwater elevation may be entered in *HP* record field 3 for computing the head used in the power equation. If a *HP* record is not used or field 3 is blank, a tailwater rating table is entered on *TE/TQ* records.

Field 4: Hydroelectric power is not generated if the average water surface elevation during the month falls below the limiting elevation specified in field 4.

Field 5: A maximum limit may be imposed on the flow volume/month that may be used to generate electric power. If field 5 is left blank, unlimited turbine discharge capacity is assumed.

Field 6: A maximum limit may be imposed on the electric energy/month that may be generated. If an energy production limit is specified, it must be greater than the monthly energy target developed based on adjusting the annual target entered in *WR* record field 3. Thus, the *HP* record field 6 limit affects only secondary energy generated in excess of the *WR* record field 3 firm energy target.

SV Record – Storage Volumes for Reservoir Storage versus Area Table

field	columns	variable	format	value	description
1	1-2	CD	A2	SV	Record identifier
2	3-8	RES	A6	AN	Reservoir identifier
3-14	9-104	TARA(I) I=1,12	12F8.0	+	Reservoir storage volumes corresponding to surface areas in same fields of the following *SA* record

SA Record – Surface Areas for Reservoir Storage versus Area Table

field	columns	variable	format	value	description
1	1-2	CD	A2	SA	Record identifier
2	3-8	RES	6x		Field not used
3-14	9-104	TARB(I) I=1,12	12F8.0	+	Reservoir surface areas corresponding to storage volumes in same fields of the preceding *SV* record

Storage volume (*SV* record) versus surface area (*SA* record) tables are used in the reservoir net evaporation-precipitation computations. A storage-area relationship may be defined optionally with a pair of *SV-SA* records or by equation coefficients provided on the *WS* record. Storage volume versus water surface elevation tables (*PV-PE* records) are used only for computing head in hydroelectric power computations. A *SV or PV* record must be followed by the corresponding *SA or PE* record. A complete set of all *PV-PE* records grouped together follows the complete set of all *SV-SA* records.

PV Record – Storage Volumes for Storage versus Elevation Table for Hydropower Right

field	columns	variable	format	value	description
1	1-2	CD	A2	PV	Record identifier
2	3-8	RES	A6	AN	Reservoir identifier
3-14	9-104	TARA(I) I=1,12	12F8.0	+	Reservoir storage volumes corresponding to surface elevations in same fields of the following *PE* record

PE Record – Surface Elevations for Storage versus Elevation Table for Hydropower Right

field	columns	variable	format	value	description
1	1-2	CD	A2	PE	Record identifier
2	3-8	RES	6x		Field not used
3-14	9-104	TARB(I) I=1,12	12F8.0	+	Reservoir surface elevations corresponding to storage volumes in same fields of the preceding *PV* record

IN Record – Inflows, Naturalized Streamflows at a Control Point

field	Columns	variable	format	value	description
1	1-2	CD	A2	IN	Record identifier
2	3-8	ID	A6	AN	Control point identifier
3	9-12	NYR	I4	+	First year for an *IN* record repeated for multiple years
				blank,0	*IN* record is for one year only; it is not repeated
4	13-16	PYR	I4	+	Year (last year to repeat if field 3 is not blank)
5	17-24	INFLOW(cp,1)	F8.0	+	Naturalized streamflow for Month 1
6	25-32	INFLOW(cp,2)	F8.0	+	Naturalized streamflow for Month 2
7	33-40	INFLOW(cp,3)	F8.0	+	Naturalized streamflow for Month 3
8	41-48	INFLOW(cp,1)	F8.0	+	Naturalized streamflow for Month 4
9	49-56	INFLOW(cp,5)	F8.0	+	Naturalized streamflow for Month 5
10	57-64	INFLOW(cp,6)	F8.0	+	Naturalized streamflow for Month 6
11	65-72	INFLOW(cp,7)	F8.0	+	Naturalized streamflow for Month 7
12	73-80	INFLOW(cp,8)	F8.0	+	Naturalized streamflow for Month 8
13	81-88	INFLOW(cp,9)	F8.0	+	Naturalized streamflow for Month 9
14	89-96	INFLOW(10)	F8.0	+	Naturalized streamflow for Month 10
15	97-104	INFLOW(11)	F8.0	+	Naturalized streamflow for Month 11
16	105-112	INFLOW(12)	F8.0	+	Naturalized streamflow for Month 12

EV Record – Net Reservoir Evaporation-Precipitation Rates for a Control Point

field	Columns	variable	format	value	description
1	1-2	CD	A2	IN	Record identifier
2	3-8	ID	A6	AN	Control point identifier
3	9-12	NYR	I4	+	First year for an *EV* repeated for multiple years
				blank,0	*EV* record is for one year only; it is not repeated
4	13-16	PYR	I4	+	Year (last year to repeat if field 3 is not zero or blank)
5	17-24	EVAPR(cp,1)	F8.0	+	Net evaporation-precipitation for Month 1
6	25-32	EVAPR(cp,2)	F8.0	+	Net evaporation-precipitation for Month 2
7	33-40	EVAPR(cp,3)	F8.0	+	Net evaporation-precipitation for Month 3
8	41-48	EVAPR(cp,1)	F8.0	+	Net evaporation-precipitation for Month 4
9	49-56	EVAPR(cp,5)	F8.0	+	Net evaporation-precipitation for Month 5
10	57-64	EVAPR(cp,6)	F8.0	+	Net evaporation-precipitation for Month 6
11	65-72	EVAPR(cp,7)	F8.0	+	Net evaporation-precipitation for Month 7
12	73-80	EVAPR(cp,8)	F8.0	+	Net evaporation-precipitation for Month 8
13	81-88	EVAPR(cp,9)	F8.0	+	Net evaporation-precipitation for Month 9
14	89-96	EVAPR(10)	F8.0	+	Net evaporation-precipitation for Month 10
15	97-104	EVAPR(11)	F8.0	+	Net evaporation-precipitation for Month 11
16	105-112	EVAPR(12)	F8.0	+	Net evaporation-precipitation for Month 12

Appendix D − TABLES Input Records

Format specifications found in the 4th column of the record description tables are defined as follows:

A4	alphanumeric (AN) label right justified in a field that is 4 characters wide
8A8	up to 8 alphanumeric labels right justified in fields that are 8 characters wide
2x	two blank spaces
F8.0	real number in field of 8 characters (either include decimal or right justify)
I8	integer number right justified in field of 8 characters

TITL Record – Titles or Headings

field	columns	variable	format	value	description
1	1-4	CD	A4	TITL	Record identifier
2	5-78	TITLE	A76	AN	Title or heading

From zero to five TITL records are entered as the first records of the input file. The alphanumeric information provided on the records is printed on the cover page and at the top of each table.

COMM or **** Record – Comments

field	columns	variable	format	value	description
1	1-4	CD	A4	***** or ** or COMM	Record identifier
2	5-no limit			AN	Comments or notes

Any number of comment records can be inserted anyplace in the input file to provide notes or comments. The comment records are not read or used in any way by the program.

PAGE Record – Title Page

field	columns	Variable	format	value	description
1	1-4	CD	A4	PAGE	Record identifier - Prints title page

ENDF Record – End of Input File

field	columns	Variable	format	value	description
1	1-4	CD	A4	ENDF	Record identifier

Records placed after the ENDF record are not read.

UNIT Record – Information for Table Headings

field	columns	variable	format	value	description
1	1-4	CD	A4	UNIT	Record identifier
2	5-9	UNIT	A5	AN blank	Volume units printed in table headings. Without a *UNIT* record, the default is AC-FT.
3	10-14	UNHP	A5	AN blank	Hydropower units printed in table headings. Without a *UNIT* record, the default is MW-HR.
4	15-19	MONTH1	A5	blank AN	Default is to begin headings with the month JAN. First month in the table headings may be entered as either JAN (default), FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, or DEC.
5	20-24	NEWPAGE	I5	blank,0,+ -1,-	Each table starts a new page. No page breaks.

Several table headings include volume and/or energy units. If a *UNIT* record is not used, the defaults are:

UNIT = AC-FT
UNHP = MW-HR

If a *UNIT* record is included in the data set with blank entries for *UNIT* and/or *UNHP*, their values are blanks. The units entered on the *UNIT* record are printed in the table headings but do not affect the data in the tables. Program *TABLES* organizes and manipulates data from *SIM* input and output files without considering units in its computations.

The listing of months in the table headings is controlled by field 4. If field 4 is left blank, the 12 monthly columns begin with January. The 12-month year may start in any other month as specified by an entry in field 4.

The variable *NEWPAGE* in field 5 is a switch specifying whether or not page breaks are inserted after each table. If *NEWPAGE* is zero (blank field 5) or positive, a page break is placed after each table causing the next table to begin a new page. A negative integer entered in field 5 results in omission of the page breaks.

A *UNIT* record is applicable to all subsequent records in the *TABLES* input data set.

1REC Record – Listing of Specified WRAP Input Records

field	columns	variable	format	value	description
1	1-4	CD	A4	1REC	Record identifier
2	5-8	KK	I4	blank, 0	List specified records
				non-zero	List all records except specified records
3	9-12	NUM	I4	+	Number of record identifiers to follow
4-20	13-80	REC	17A4	AN	Identifiers of specified WRAP input records (REC(I),I=1,NUM)

1SUM Record – Water Rights Summary

field	columns	variable	format	value	description
1	1-4	CD	A4	1SUM	Record identifier
2	8	KK	I4	blank, 0	Summary by control point with only totals printed
				1	Summary by control point
				2	Summary by type of use
				3	Summary by water right type
				4	Summary by groups as defined by GO record

1SRT Record – Listing of Sorted Water Rights

field	Columns	variable	format	value	description
1	1-4	CD	A4	1SRT	Record identifier
2	8	KK	I4	blank, 0	Listing of rights in priority order
				1	Listing of rights by control point in priority order
				2	Listing of rights by type-of-use in priority order
				3	Listing of rights by water right type in priority order

Time Series Records

The following types of input records build tables in the same optional formats, with the only difference being the selection of variable to be tabulated. The items in parenthesis indicate whether the variable is associated with a control point, water right, and/or reservoir/hydropower project.

2NAT Record – Naturalized Streamflow (control points)
2REG Record – Regulated Streamflow (control points)
2UNA Record – Unappropriated Streamflow (control points)
2CLO Record – Channel Loss (control points)
2CLC Record – Channel Loss Credits (control points)
2RFR Record – Return Flow Entering at this Control Point (control points)
2URR Record – Regulated Flow at this Control Point from Upstream Reservoir Releases (control points)
2STO Record – Reservoir Storage (control points, water rights, reservoirs)
2EVA Record – Reservoir Evaporation-Precipitation Volume (control points, water rights, reservoirs)
2DEP Record – Streamflow Depletion (control points, water rights)
2TAR Record – Diversion Target (control points, water rights)
2SHT Record – Diversion Shortage (control points, water rights)
2DIV Record – Diversion (control points, water rights)
2RFL Record – Return Flow (water rights)
2ASF Record – Available Streamflow (water rights)
2ROR Record – Releases from Other Reservoirs (water rights)
2IFT Record – Instream Flow Target (instream flow rights)
2IFS Record – Instream Flow Shortage (instream flow rights)
2HPS Record – Hydropower Shortage (+) or Secondary Energy (-) (reservoir/hydropower)
2HPE Record – Energy Generated (reservoir/hydropower)
2RID Record – Inflows to Reservoir from Streamflow Depletions (reservoir/hydropower)
2RIR Record – Inflows to Reservoir from Releases from Other Reservoirs (reservoir/hydropower)
2RAH Record – Releases Accessible to Hydropower (reservoir/hydropower)
2RNA Record – Releases Not Accessible to Hydropower (reservoir/hydropower)
2EPD Record – Evaporation-Precipitation Depths (reservoir/hydropower)

Continued on next page.

Time Series Records – All Record Types Listed on Preceding Page

field	columns	variable	Format	value	description
1	1-4	CD	A4	page 112	Record identifier from the list on preceding page.
2	8	TA	I4	Blank,0	Do not develop annual row/monthly column table.
				1	Develop table with annual rows and monthly columns.
3	12	PT	I4	Blank,0	Do not activate either HEC-DSS or text file option.
				1	Develop columns of monthly data in text file.
				2	Develop columns of annual totals or means in text file.
				3	Develop columns of 12 monthly means in text file.
				4	Develop HEC-DSS monthly time series records.
				5	Develop HEC-DSS annual time series records.
4	16	NEW	I4	0	Write columns; next record starts a new table.
				1	Add more columns to existing table or start first table.
5	20	ID	I4	0	Develop tables for default ID or for control points.
				1	Develop tables for water rights.
				2	Develop tables for reservoirs.
				3	Develop tables for water right groups.
6	24	NUM	I4	0	Tables for all control points (ID=0), rights (ID=1), or reservoirs (ID=2). NUM cannot be zero if ID=3.
				–	Develop tables for the NUM control points, water rights, or reservoirs listed on the previous record.
				+	Number of control points, water rights, reservoirs, or water right groups to follow (up to 80, eight per record)
7-14	25-88	IDEN	8(2x,A6)	AN	Identifiers of control points (ID=0), water rights (ID=1), reservoirs (ID=2), water right groups (ID=3) to include in the table. IDEN(ID,I), I=1,NUM
	25-88	IDEN8	8A8		
	25-152	IDEN16	8A16		
				blank	If NUM is zero or negative.

Explanation of Time Series Input Record Fields

Field 1: One of the 25 alternative record identifiers listed on the preceding page is entered in field 1. Variables are selected by this record identifier.

Field 2: A set of one or more tables with rows for years and columns for months is created by entering the integer 1 in field 2. The tables are written to the TAB file. Annual totals or means are included in the table along with the monthly amounts.

Field 3: Either columns of data may be written to the TAB text file or HEC-DSS records may be written to the binary DSS file. The data may include either monthly amounts or annual means/totals but not both.

A table activated by entering a 1, 2, or 3 in field 3 consists of a single column for each variable with multiple variables being included as separate columns in the same table. This format is designed to be read by Microsoft Excel or other spreadsheet programs for plotting or additional computational manipulations. The column may contain either the entire time series of monthly data (PT=1 in field 3), annual totals or means for each year of the simulation (PT=2), or a set of 12 means for each of the 12 months of the year (PT=3). The parameter *NEW* in field 4 controls whether a column is included in the same table with previous columns.

Options 4 and 5 in field 3 consist of storing the monthly or annual time series as binary records in a HEC-DSS file. These options allow use of the graphing and computational capabilities provided by HEC-DSSVue.

Field 4: Field 4 is relevant only if a columnar tabulation is activated by entering a 1, 2, or 3 in field 3. Each variable is tabulated as a single column in a table. The parameter *NEW* in field 4 specifies whether to place another column in the current table or to create another new table. Each table can include any number of columns up to a limit of 100 columns. At least one record must have a *NEW* of zero in order to write the table.

Field 5: The time series variables are associated with either control points (ID=0), water rights (ID=1), reservoirs (ID=2), and/or water right groups as indicated in Table 4.10. For those variables associated with only one ID, field 5 may be left blank. For variables that may be associated with more than one ID, an ID selection is entered in field 5. Summation of the data for all water rights in a group (ID=3) may be tabulated by 2STO, 2EVA, 2DEP, 2TAR, 2SHT, or 2DIV records.

Field 6: The default is to include all of the control points (ID=0), water rights (ID=1), or reservoirs (ID=2) found in the *SIM* OUT file. Optionally, lists of control points, water rights, reservoir/hydropower projects, or water right groups may be entered in fields 7 through 14 to specify inclusion in the *TABLES* tables. Water right groups may be selected only by listing them in fields 7-14.

The number of identifiers to be read in fields 7-14 do not necessarily have to be repeated for multiple records. A negative value for NUM may be entered in field 6 to indicate that the list read from the previous record is to be repeated. For example, a −32 tells TABLES to use the first 32 identifiers that remain in memory from a previous record. The 2REL, 2FREQ, 2SCP, 2SWR, and 2SRE records also enter identifiers into memory in this same repeatable format.

Fields 7-14: Up to 8 identifiers may be entered on a single record. Additional records with blank fields 1-6 may be used to extend the number of identifiers associated with a single set of tables or columns. Up to 80 identifiers on 10 records may be entered as a group. Any number of record groups may be entered.

2REL Record – Water Supply Diversion or Hydroelectric Energy Reliability Summary

field	columns	variable	format	value	description
1	1-4	CD	A4	2REL	Record identifier
2	8	TFLAG	I4	0, blank	Optional feature is not used.
				1,+	Diversion summary table is added at the end of the reliability table. A 2RET record must follow.
3	12	RFLAG	I4	0,blank	N = number of months with non-zero targets
				1,+	N = NYRS*MONTHS for $R_P = (n/N)*100\%$
4	16	ID	I4	0	Table includes selected control points.
				1	Table includes selected water rights.
				2	Table includes selected hydropower reservoirs.
				3	Table includes selected water right groups.
5	20	MONTH	I4	0,blank	All months are included in the computations.
				+	The month for which the analysis is performed.
6	24	NUM	I4	0	Include all control points (ID=0), water rights (ID=1), or reservoirs (ID=2) in table.
				+	Number of water rights, reservoirs, water right groups, or control points to follow (1 to 80; 8 per record)
				–	NUM identifiers from previous record are repeated.
7-14	25-88	IDEN	8(2x,A6)	AN	Identifiers of control points (ID=0), water rights (ID=1), reservoirs (ID=2), or water right groups (ID=3) to include in table (IDEN(ID,I),I=1,NUM)
	25-88	IDEN8	8A8		
	25-152	IDEN16	8A16		
				blank	If NUM is zero or negative.

2RET Record – Supplemental 2REL Summary Table

field	columns	variable	format	value	description
1	1-4	CD	A4	2RET	record identifier
2	5-12	TAR	F8.0	+	Annual diversion or hydropower target
				−1, −	adopt target from *WRAP-SIM* output file

Explanation of 2REL/2RET Record Fields

Field 2: *TFLAG* in field 2 adds a table showing the diversion target, diversion, shortage, and volume reliability for the total of all the control points, water rights, reservoirs, or groups included in the reliability table, based on a total diversion target specified by the user. This option requires that a *2RET* record follow the *2REL* record. The only entry on the *2RET* record

is the diversion target to be adopted for the add-on summary, which if left blank defaults to the summation of the pertinent targets from the *SIM* output file.

The supplemental *2RET* table allows a target to be input for use in computing volume reliability for the aggregate of all of the rights in the *2REL* table. Several water right *WR* records with associated *SO*, *TO*, *DI*, *WS*, and other supporting records may be combined to represent a particular water use requirement. A *2REL* record will create a table containing a line for each component *WR* record. However, model users may be interested in the combined reliability of the total water use requirement rather than the individual reliabilities associated with its component *WR* records. The complexity of interpreting the overall reliability from the component rights in the reliability table depends upon the options applied in building the targets in *SIM*. The totals line at the bottom of the *2REL* table is applicable if the table contains a number of separate rights, but may not meaningfully reflect certain combinations of intermediate targets built with combinations of *WR*/*SO/TO/DI* records.

Field 3: Reliability computations may be based either on using the simulation results from only the months with non-zero targets or using all 12 months of all years regardless of the target amounts.

Field 4: For control points (ID=0), water rights (ID=1), and water right groups (ID=3), reliabilities are computed for water supply diversions. For hydropower reservoirs (ID=2), reliabilities are computed for electric energy generation. *TABLES* reads the data for control points (ID=0) from the control point records (Table 2.4) in the *SIM* OUT file. The data for water rights (ID=1) and water right groups (ID=3) are from the water right records (Table 2.3) in the *SIM* OUT file. The data for the hydropower reservoirs (ID=2) are from the reservoir/hydropower records (Table 2.5).

For water right groups, the computed reliabilities are for the aggregation or summation of the diversions for all the water rights included in the group. For control points, reliabilities are for the summation of the diversions for all the water rights located at the control point.

Field 5: If a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 is entered for *MONTH* in field 4, reliabilities are computed for the specified month. For example, reliabilities for meeting a diversion target in August (*MONTH* = 8) may be computed. The default is to include is all months in the simulation, subject to the optional *RFLAG* constraint of field 3.

Field 6: A blank or zero field 6 results in all of either the control points (ID=0 in field 5), water rights (ID=1), or reservoir/hydropower projects (ID=2) included in the *SIM* output file being included in the reliability table. Optionally, lists of control points, water rights, reservoir/hydropower projects, or water right groups may be entered in fields 7 through 14 for inclusion in the table. Water right groups may be selected only by listing them in fields 7-14. A negative value for NUM in field 6 indicates that the list read from the previous record is to be repeated. The time series, 2REL, 2FREQ, 2SCP, 2SWR, and 2SRE records enter identifiers into memory in the same format that may be repeated with a negative NUM.

Fields 7-14: Up to 80 identifiers (*NUM* = 80 in field 6) on ten records (8 identifiers per record) may be included in a single table. Any number of tables may be created using multiple 2REL records. Water rights *IDEN16* are unique identifiers for individual rights; so diversions and shortages are not aggregated. If multiple rights in the *SIM* OUT file have the same identifier, only the first right with *IDEN16* is used.

2FRE Record – Flow-Frequency or Storage-Frequency Relationships

field	columns	variable	format	value	description
1	1-4	CD	A4	2FRE	Record identifier
2	5-8	ID	I4	1	Naturalized flows
				2	Regulated flows
				3	Unappropriated flows
				4	Reservoir storage associated with a control point
				–4	Reservoir storage with only totals included in table
				5	Reservoir storage associated with a water right
				–5	Reservoir storage with only totals included in table
				6	Instream flow shortage for an *IF* record right
3	9-12	MONTH	I4	0,blank	All months are included in the computations.
				+	The month for which the analysis is performed.
4	16	NUM	I4	0	Include all control points or water rights in table
				+	Number of control points or rights to follow (80 maximum, eight per record)
				–	NUM identifiers from previous record are repeated.
5-12	17-80	IDCP IDEN16	8(2x,A6) 8A16	AN	Identifiers of control points (ID=1-4) or rights (ID=5,6) to include in table. IDEN(ID,I), I = 1,NUM
				blank	If NUM is zero or negative

2FRQ Record – Frequency for Specified Flow or Storage

field	columns	variable	format	value	description
1	1-4	CD	A4	2FRQ	Record identifier
2	5-8	ID	I4	1	Naturalized flows
				2	Regulated flows
				3	Unappropriated flows
				4	Reservoir storage associated with a control point
				5	Reservoir storage associated with a water right
				6	Instream flow shortage for an *IF* record right
3	12	MONTH	I4	0,blank	All months are included in the computations.
				+	The month for which the analysis is performed.
4	16	NM	I4	+	Number of flows or storages entered for *TABLES* to determine frequencies (NM may range from 1 to 7)
5	17-24 17-32	IDEN IDEN16	2x,A6 A16	AN	Identifier of control point (ID=1-4) or water right (ID=5,6)
6-12	25-80 33-88	QF(I) I=1,NM	7F8.0	+	Streamflows (ID=1,2,3), storage (ID=4,5), or instream flow shortage (ID=6) for which to compute frequency

2RES Records – Reservoir Storage Tables

First 2RES Record

field	Columns	variable	format	value	description
1	1-4	CD	A4	2RES	Record identifier
2	8	TABLE	I4	0	All three tables are created.
				1	Storage contents as a percentage of capacity table.
				2	Storage draw-down duration table is created.
				3	Storage reliability table is created.
				4	Both draw-down and reliability tables are created.
3	11-12	MONTH	I4	0,blank	All months are included in the computations.
				+	The month for which the analysis is performed.
4	15-16	NUM	I4	+	Number of reservoir identifiers in following fields.
5-24	17-176	IDEN(res) res=1,20	20(2x,A6)	AN	Reservoir identifiers

Second 2RES Record – Total Storage Capacity (required)

field	columns	variable	format	value	description
1	1-4	CD	A4	2RES	Record identifier
2-4	5-16		12X		Blank or comments (not read by *TABLES*)
5-24	17-176	C1(res) res=1,20	20F8.0	+	Total storage capacity in each reservoir (C_1).

Third 2RES Record – Inactive Storage Capacity (optional)

field	columns	variable	format	value	description
1	1-4	CD	A4	2RES	Record identifier
2-3	5-8		12X		Blank or comments (not read by *TABLES*)
5-24	17-176	C2(res) res=1,20	20F8.0	+	Inactive storage capacity in each reservoir or bottom of the storage zone being considered (C_2).

The third 2RES record is generally optional, with all C_2 defaulting to zero. However, the third record is required even if the C_2 are zero if followed by another set of 2RES records.

Explanation of 2RES Records

A set of 2RES records results in storage contents being read from reservoir records in the *SIM* output file. A maximum of 20 reservoirs can be included. The reservoir identifiers are provided on the first 2RES record. The C_1 storage capacities are provided on the required second 2RES record. The C_2 storage capacities are provided on the optional third record. C_2 is assumed zero for all reservoirs if the third 2RES record is not provided. The third 2RES record is required if followed by another set of 2RES records. C_1 and C_2 are the storage capacities at the top and bottom of the storage zone being considered. Typically, C_1 will be the total conservation storage capacity and C_2 will be either zero or the inactive storage capacity. However, the pool zone may be defined to fit the application.

The set of 2RES records develop three different tables selected by the entry for *TABLE* in field 2 of the first record.

The first type of table is a tabulation of end-of-period reservoir storage contents expressed as a percentage of a user-specified storage capacity, with one column per reservoir.

$$\text{storage as percentage of capacity} = \left(\frac{S - C_2}{C_1 - C_2} \right) 100\%$$

where S is the end-of-month storage content and C_1 and C_2 are the capacities at the top and bottom of the storage zone being considered. The percentage storage tabulation is useful is comparing the relative storage of reservoirs in a system of multiple reservoirs.

The second table is a storage draw-down duration relationship expressed in terms of the number of months for which the draw-down equaled or exceeded specified percentages of storage capacity of the zone defined by the equation above.

The third table is a storage reliability relationship expressed in terms of the percentage of months for which the contents equaled or exceeded specified percentages of storage capacity of the zone defined by the equation above.

If a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 is entered for *MONTH* in field 3 of the first *2RES* record, tables are constructed for the specified month. The default is to consider all months in the analysis of simulation results.

2SCP Record – Summary Tables for Control Points

field	columns	variable	format	value	description
1	1-4	CD	A4	2SCP	Record identifier
2	8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables
3	9-12	NUM	I4	blank ,0	Develop tables for all control points.
				+	Number of control points to follow.
				–	NUM identifiers from previous record are repeated.
4-11	13-76	IDCP	8(2x,A6)	AN	Identifiers of control points for which to develop tables. IDCP(ID,I), I = 1,NUM

2SWR Record – Summary Tables for Water Rights

field	columns	variable	format	value	description
1	1-4	CD	A4	2SWR	Record identifier
2	5-8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables
3	9-12	NUM	I4	blank,0	Develop tables for all water rights.
				+	Number of water rights to follow.
				–	NUM identifiers from previous record are repeated.
4-11	13-140	IDEN16	8A16	AN	Identifiers of water rights for which to develop tables. IDEN16(ID,I), I = 1,NUM
				blank	If NUM is zero or negative

2SCP, 2SWR, 2SGP, and 2SRE records are essentially the same except *IDCP and IDRES* denote control point and reservoir identifiers which may have a maximum of six characters, *IDEN8* denotes water right group identifiers which may consist of up to eight characters, and *IDEN16* is for water right identifiers which may be up to 16 characters long.

Water right groups must be listed explicitly on the 2SGP record. *NUM* cannot be zero for a water right group operation.

TABLES reads the data for 2SCP and 2SBA tables from the control point records in the *SIM* output file. The data for the 2SWR and 2SGP tables are from the water right records in the *SIM* output file. The data for the 2SRE table are from the reservoir/hydropower records in the *SIM* output file.

2SGP Record – Summary Tables for Water Right Groups

field	columns	Variable	format	value	description
1	1-4	CD	A4	2SGP	Record identifier
2	5-8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables
3	9-12	NUM	I4	+	Number of water right groups to follow.
				–	NUM identifiers from previous record are repeated.
4-11	13-140	IDEN8	8A8	AN	Identifiers of water right groups for which to develop tables. IDEN8(ID,I), I = 1,NUM
				blank	If NUM is negative

2SRE Record – Summary Tables for Reservoirs

field	columns	variable	format	value	description
1	1-4	CD	A4	2SRE	Record identifier
2	5-8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables
3	9-12	NUM	I4	0	Develop tables for all reservoirs.
				+	Number of reservoirs to follow.
				–	NUM identifiers from previous record are repeated.
4	13-76	IDRES	8(2x,A6)	AN	Identifiers of reservoirs for which to develop tables. IDRES(ID,I), I = 1,NUM
				blank	If NUM is zero or negative.

2SBA Record – Aggregate Summary Table for the Entire River Basin

field	column	variable	format	value	description
1	1-4	CD	A4	2SBA	Record identifier
2	8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables